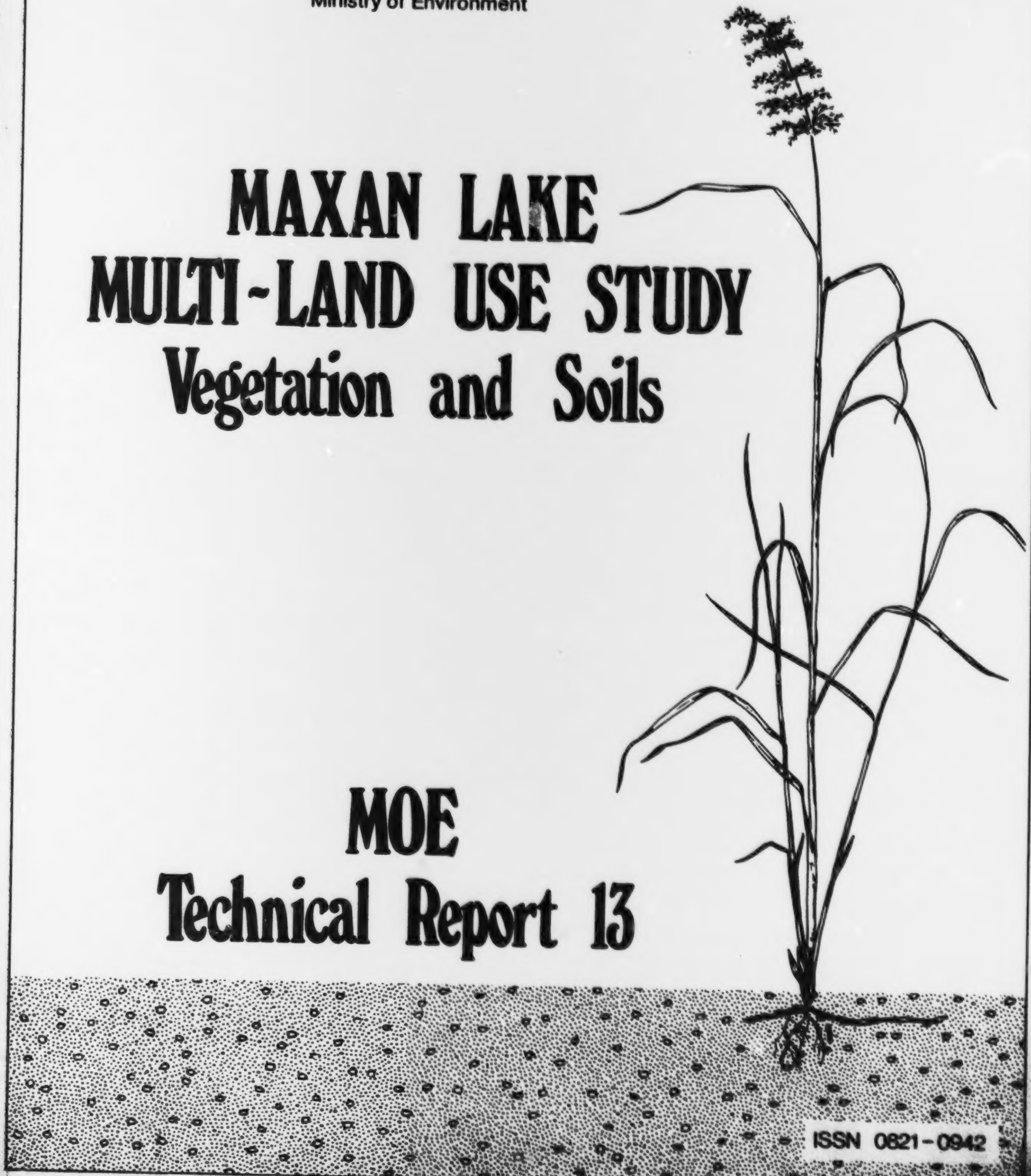
BC
Ministry of Environment

# MAXAN LAKE
# MULTI-LAND USE STUDY
## Vegetation and Soils



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## Technical Report 13

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Ministry of Environment

## MOE Technical Report 13

# MAXAN LAKE - MULTI - LAND USE STUDY: VEGETATION AND SOILS

C.E. Thompson

SURVEYS AND RESOURCE MAPPING BRANCH

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# CHAPTER ONE
# INTRODUCTION

## 1.1 OBJECTIVES

In 1972, under the initiative of the Ministry of Agriculture and Food, numerous agencies within the Ministry of Environment - Surveys and Resource Mapping Branch, Fish and Wildlife Branch and Air Studies of the Waste Management Branch - cooperated in a multi-land use research study to inventory and analyze the soils, terrain, vegetation, climate, wildlife and agriculture potential. The area chosen is southeast of Houston in the Maxan Creek Valley (Figure 1.1).

The general objectives of this study, for the Vegetation Unit of the Surveys and Resource Mapping Branch, were to design a framework in order to:

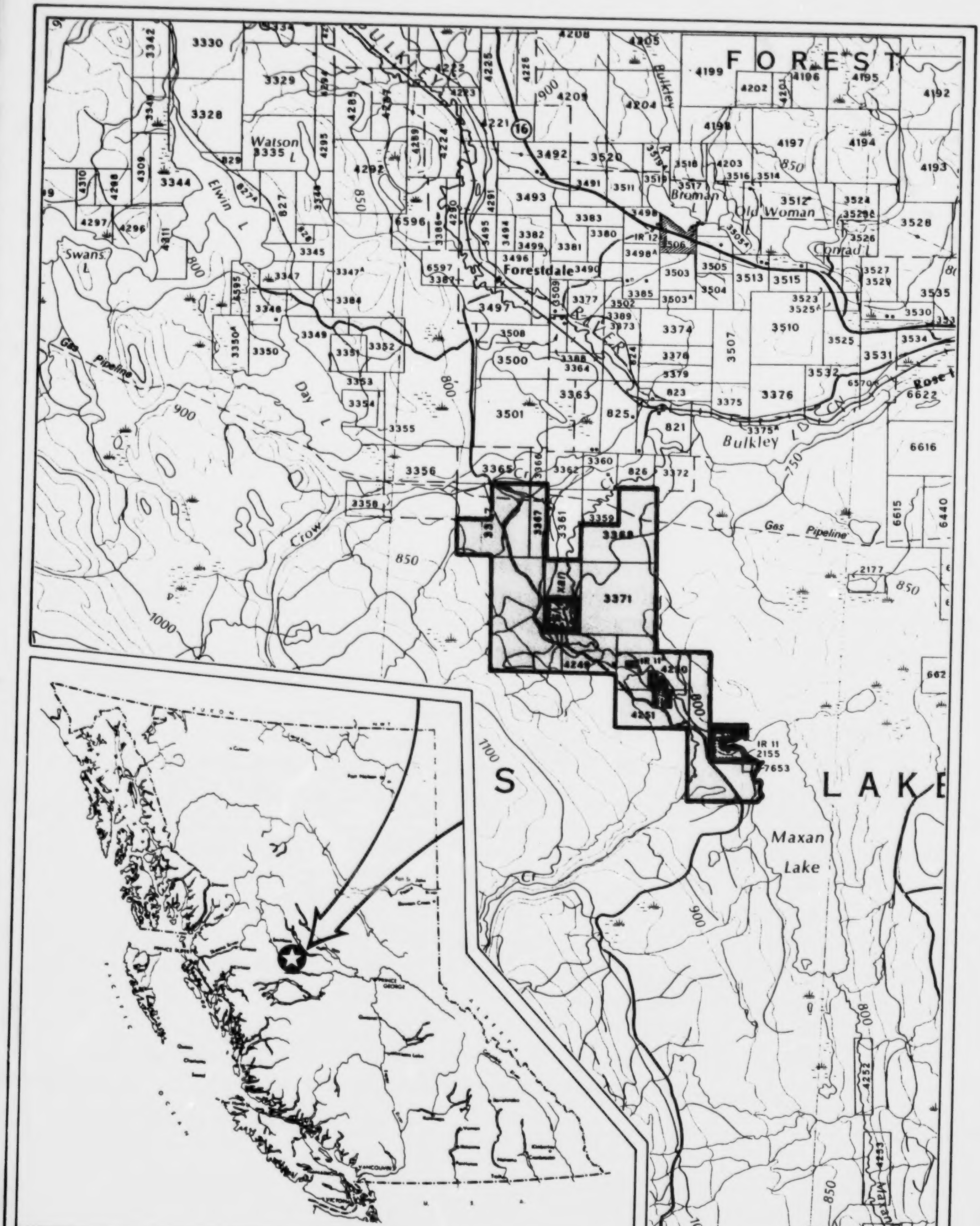
a) evaluate the vegetation and soil resources.

b) evaluate the changes that occurred within the ecosystem as a result of various management and land use practices as they relate to vegetation and soils.

An initial report containing the vegetation and soil data from 1972 to 1978 was drafted and is in the process of being published by the Ministry of Agriculture and Food (McNeil, in preparation). This main report explains the history, development and results of the first six years of the project.

In 1982, Subproject II was re-sampled. The specific objectives of this subproject were to assess the effects of the treatments - land clearing, fertilization, seeding a grass-legume mixture, planting tree seedlings and to determine biomass production and soil properties on each site.

This report is a summary of the findings from the 1982 field studies. All data prior to 1982 has been extracted from the initial report.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Bulkley
Broman L
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Conrad L
Watson L
Elwin L
Swans L
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Maxan Lake
Maxan
Gas Pipeline
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Rose L
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4296
4310
4311
900
850
800
750
1000
1100
4252
4253
PRINCE RUPERT
PRINCE GEORGE
VANCOUVER
VICTORIA
YUKON
PACIFIC OCEAN

## 1.2 TERRAIN [1]

Geographically, the study area falls within the western side of the Nechako Plateau physiographic subdivision (Holland, 1976) which is characterized by relatively wide valleys and rounded hills. The area is covered by a mantle of till which is underlain by bedrock of volcanic origin consisting of basalt, andesite and dacite. The till mantle within the project area varies considerably in thickness from deep deposits on sloping landscapes to shallow deposits on some local hills and ridges.

## 1.3 SOILS [1]

The soils within the project area fall within the Deserters Soil Association (Runka, 1972). The soil development is predominantly Brunisolic Gray Luvisol and can be described as transitional to Podzolic Gray Luvisol. The topography ranges from slightly sloping to moderate and strongly rolling. Textures become finer with depth normally ranging from gravelly loam to gravelly clay loam. Where the parent material is shallow to bedrock, soil textures become coarser (gravelly loam to very gravelly sandy loam) and the total coarse fragment fraction increases dramatically. The coarse fragment content in these soils ranges from ten to thirty-five percent, mostly of gravel size (2 mm to 7.5 cm). Cobbles and stones are present but are minor in extent with the exception of soils near shallow to bedrock areas. The soils are predominantly well drained and moderately to slowly pervious.

The organic litter on the surface tends to be thin and variable in depth, particularily in the cleared area. The reddish brown Bm (Bf) horizons tend to be thin, however iron and aluminium levels (pyrophosphate) indicate that these horizons often qualify for Podzolic Gray Luvisols. The Bm (Bf) horizons are underlain by a whitish Ae leached horizon which is transitional to the clay enriched Bt horizon. The Bt horizon restricts both water and root penetration, and normally occurs between 30 and 50 cm from the surface and is often 25 cm or more in thickness. The clay enriched Bt horizon is underlain by very hard compact CB and C horizons.

---

[1] The terrain and soil section was compiled by J. Jungen, Pedologist, Ministry of Environment, Surveys and Resource Mapping Branch, Soil Unit, Kelowna, British Columbia.

The project area occurs on somewhat drier more exposed southwest slopes with only minor areas where surface runoff is slow and seepage is present. Consequently, the soils are mostly well drained, although moderately well drained soils occur on gentle to level sloping landscapes. Areas which receive additional water through seepage from high slopes are imperfectly drained. These areas have Ah horizons and are classified as Gleyed Gray Luvisols (eg. site Mx-1). These imperfectly drained soils have mottled and dull coloured profiles indicating the influence of a high water table for part of the year. Topography and landscape position are all important when determining the extent of these imperfectly drained soils.

The parent material is relatively uniform away from the influence of gully erosion and rock outcrops. The project area, to a minor but significant extent, is affected by both gullying and bedrock. The gully pattern has been stable for many hundreds of years, however the soils along them have been influenced mainly by higher coarse fragment content, gravelly horizons, and steeper slopes. The water storage capacity of these areas are lower. Similarly, some local ridge tops are shallow to bedrock - these areas have higher cobble, stone, and gravel content. Textures are coarser and water storage capacity is significantly lower.

Cation exchange capacities range from 10 to 25 meg/100 g and base saturations increase to 100% with depth. Nitrogen levels are relatively high in the organic L-F-H layer but otherwise very low to extremely low in the mineral horizons. The pH levels are very acidic in the upper organic layers, very strongly acid in the upper Bm horizons and slowly decrease to slightly acid at depth.

For representative detailed soil profile descriptions, and physical and chemical analysis contact the B. C. Soil Information System, British Columbia Ministry of Environment, Victoria.

## 1.4 VEGETATION

The Maxan Lake study area lies in the Subboreal white spruce-alpine fir zone of the Subboreal Vegetation Region. The forested area surrounding the clearcut is composed of a moderately dense stand of overmature seral lodgepole pine with white spruce sparsely regenerating in the shrub layers. The open, tall, shrub layer is mainly composed of Sitka mountain alder. Roses, soopolallie and western thimbleberry are found in the low shrub layer. The herb layer is composed of showy aster, American vetch and cream-coloured peavine. The moss layer is dense and dominated by Pleurozium schreberi.

This vegetation is represented by plot 73-13, the forested control plot.

In the cleared area the vegetation is variable. It is dependent on the treatments, the site conditions and the succession of species. The open to dense shrub layer is composed of regenerating lodgepole pine, prickly rose and birch-leaved spirea. Trembling aspen, white spruce, and a minor amount of (less than 10% cover) Sitka mountain alder are occasionally present. In a few plots (Mx-1, 73-12, and Mx-2) lodgepole pine has progressed to the tall shrub layer.

The dominant vegetation in the herb layer can be divided into two groups:

1) plots seeded with a grass-legume mixture (Mx-1, 73-12 and 73-05)
2) plots not seeded with the grass-legume mixture (73-08, 73-03, Mx-2, 73-04 and 73-11).

In the former case the dominant herbs are fireweed, red fescue, orchard grass and Douglas' aster. However, in the unseeded plots bluejoint small reed grass, rough-leaved rice grass, showy aster, Douglas' aster and fireweed dominate. Both fireweed and Douglas' aster are common to both groups.

A complete species list for each plot plus a reference list for the botanical names is given in Appendix A.

# CHAPTER TWO
# MATERIALS AND METHODS

## 2.1 SAMPLING DESIGN

Subproject II was divided into six parallel strips. Each strip was subjected to a set of treatments. The treatments were chosen so that each strip differed from one of the other strips in only one treatment. Consequently, one strip served as a comparison control with respect to the other. In this manner the effect of each treatment could be ascertained.

In order to determine the effect of a single treatment - logging, an untreated control site, was cleared (plot no. 73-08). Another control site was left in its original state to assess the consequences of tree clearing on soils and vegetation (plot no. 73-13).

The plots were located to be representative of specific natural site conditions. Therefore, when evaluating the results the site characteristics of each plot is considered. Refer to the report by McNeil (in prep.) for a map depicting the sampling design, the location of the plots and the treatments.

## 2.2 TREATMENTS

Five separate treatments, in various combinations, were applied to Subproject II. These were: land clearing, seeding a grass-legume mixture, application of fertilizer, planting lodgepole pine seedlings and grazing.

As stated earlier, the area was logged before the commencement of the project to simulate a clearcut logging situation. However, the subsequent clean-up operation was more intensive than would normally be the case in a clearcut for timber harvesting. The results are more representative of land clearing for agricultural purposes.

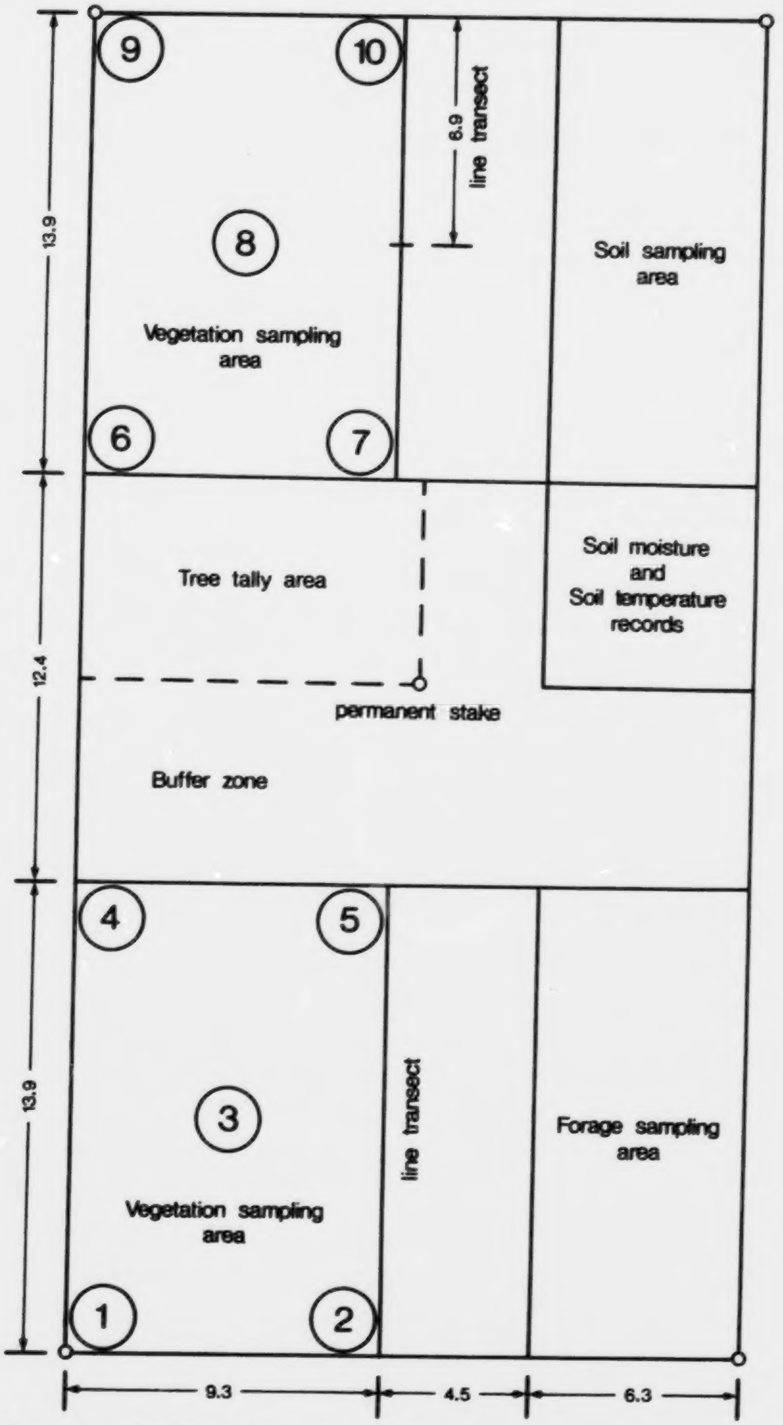
9
10
6.9
line transect
8
Vegetation sampling area
6
7
Soil sampling area
13.9
Tree tally area
Soil moisture and Soil temperature records
permanent stake
Buffer zone
12.4
4
5
3
line transect
Forage sampling area
Vegetation sampling area
1
2
13.9
9.3
4.5
6.3

Figure 2.1 Vegetation - Soil Research Plot Layout (in metres)

The grass mixture, recommended by the British Columbia Ministry of Agriculture and Food, Kamloops, which was broadcast at eleven and two tenths kilograms per hectare (11.2 kg/ha), consisted of: common timothy -20%, red fescue -20%, orchard grass -20%, brome grass -20%, alsike clover -10%, and alfalfa -10%.

One hundred and twelve kilogram per hectare (112 kg/ha) of 26-13-0+ S (11%) was applied by manual cyclone seeders, operated by four people walking abreast. The use of the above fertilizer was based on analysis of soil samples from plots MX-1 and MX-2.

Fifteen thousand, six hundred (15,600) lodgepole pine seedlings from the British Columbia Forest Service nursery at Surrey were planted by the British Columbia Forest Service with eight-foot spacing using the mudpack method (Pelton Reforestation Ltd., personal communication[1]).

Grazing commenced in 1976.

## 2.3 PLOT LAYOUT

A plot 40.2 m by 20.1 m (.08 ha) was delineated (Figure 2.1). Iron stakes were placed at the four corners and in the centre of the plot. Nylon twine was strung around the corner stakes. Also, a white post demarcated the centre of the plot.

The plot consists of:

1. Two 9.3 m by 13.9 m areas for the collection of vegetation data. Also contained within each area are five circular plots with a radius of 2.3 m; their centers were permanently marked with iron stakes.

[1] Pelton Reforestation Ltd., Vancouver

2. The 20.1 m by 10.1 m tree tally area will replace the circular plots when the trees on the circular plots reach a size that they cannot be sampled satisfactorily.
3. Areas for soil, forage, soil moisture and soil temperature sampling were set out.

## 2.4 COLLECTION OF DATA

The collection of data, parameters measured, and time of measurement is summarized in the Data Collection Plan - Subproject II (refer to McNeil, in prep.).

### 2.4.1 Vegetation

All the vegetation data, with the exception of biomass, were collected from plots 73-13, 73-08, 73-05, 73-11, 73-04, 73-03, Mx-1, 73-12, Mx-2 and recorded on the Vegetation Data Form. Biomass samples were collected on plots 73-08, Mx-1, 73-12 and Mx-2. The data consists of the following measurements:

(i) Species frequency - for each of the 10 subplots the presence of species was checked. Total frequency is expressed as the percentage of the subplots the species was present in. Species frequency is an objective measure for monitoring changes in the vegetation. If a species was present in all subplots, the frequency percentage is assigned the number ninety-nine in order to remain within the limits of a two digit number (computer programme limitation).

(ii) Cover (estimated): on .08 of a hectare. Cover is estimated as the percentage of the ground area covered by the vertical projection of the outline of the plant crown.

(iii) Biomass - the vegetation (except tall shrubs and trees) was clipped at ground level from a square metre plot in the biomass sampling area. The clippings were sorted by species for each plot, then air-dried at a constant temperature (73.4°C for 24 hours) in order to give comparable results. The samples were weighed, then ground for analysis for the following nutrients: nitrogen, calcium, phosphorus, copper, iron, zinc, magnesium, potassium, boron, manganese, sulfur and selenium. The analyses were performed by the Soil Testing Laboratory, Ministry of Environment, Kelowna, British Columbia. The results of the analyses are listed in Appendix B. The analytical methods applied follow McKeague (1976). More detailed information on the methods can be obtained from the Soil Testing Laboratory, Kelowna, British Columbia.

### 2.4.2 Forestry

The following data was collected:

(i) Seedling: counts, height growth - the seedlings were counted and the height of each was measured and recorded in the 10 subplots of each plot.

### 2.4.3 Soil

The following soil parameters were recorded for plots 73-13, 73-08, Mx-1, 73-12, Mx-2, 73-11, 73-03 and 73-05.

(i) Natural soil moisture - this parameter was determined from samples taken at the indicated depths (Table 2.1). These depths were chosen following a determination of the soil profile horizons. In all profiles, each depth falls within a specific horizon.
Soil moisture samples were collected in standard moisture tins supplied by the Soil Laboratory Section (Surveys and Resource Mapping Branch, Kelowna, British Columbia). This measurement permits an estimate of when moisture deficiencies may limit plant growth.

(ii) Profile sampling - samples were collected from the described horizons.

(iii) Profile description - the soil profiles were described according to the field reconnaissance practices in use with the Soil Unit of the Survey and Resource Mapping Branch.

The descriptions serve - to relate the soils of the area to the soil associations previously described by Runka (1972)

- to characterize the soils of the study area
- to obtain an understanding of the ecological processes that are in effect (nutrient and moisture budgets)

(iv) Chemistry and Physics - the following specific tests were applied only to selected horizons or depths. These are shown in Table 2.1.

Mechanical analysis - is the determination of the various amounts of the different separates in a soil sample (Canada Dept. of Agriculture, Research Branch, 1976). This determination aids in the idenfication of the Bf and Bt horizons.

Moisture tension - was calculated for 15 and 1/3 bar. Fifteen bar moisture tension corresponds to the permanent wilting point of a plant. This is the point at which the plant can no longer remove appreciable quantities of water, or the water remaining in the soil at this point is unavailable to plants in a quantity or at a rate that will maintain turgidity of the plant (Salisbury and Ross, 1969). The amount of water left in the soil at this point will vary considerably according to the texture of the soil.

One-third bar moisture tension corresponds to moisture equivalent. This is approximately the same constant as field capacity, which is reached when the soil contains its full complement of capillary water.

Bulk density - is the mass of dry soil per unit volume (Canada Department of Agriculture, Research, 1976). This constant is a measure of the compactness of the soil. It also supplies a measure of the amount of pore space available for root growth.

Atterberg limits - describe soil consistency. A liquid limit and a plastic limit express the water content of a soil at these points (Hough, 1957).

Nutrition:

Total carbon - the percentage of organic carbon is used to define mineral horizons and layers (e.g. Bf, Ah, Bh) (Canada Soil Survey Committee, 1978).

Total nitrogen - this test was originally conducted to monitor and determine the effects of nitrogen fertilizer through the soil profile over a period of time.

Exchangeable cations - provide an indication of the fertility of the soil.

Cation exchange capacity - provides an indication of the ability of the soil to retain plant nutrients, important to soil management and determination of ecosystem sensitivity.

Fe and Al pyrophosphate - is used to define mineral horizons and layers - Bf, Bgf, Bh, and Bfj (CSSC, 1978).

Phosphorus: total and available - value of the measure of fertility of the soil.

Sulphur: total and available - value of the measure of fertility of the soil.

# CHAPTER THREE
# RESULTS

## 3.1 VEGETATION

### 3.1.1 Vegetative Recovery and Development

During the first ten years following logging on Subproject II the species composition on the plots changed and a pattern of succession arose which were in some cases created by the seeding of grass, planting of trees or fertilizer. This pattern is initiated by a herb stage which is followed in turn by shrubs. The dominant herbs were the seeded grasses, shade intolerant natural grasses and fireweed. Taking longer to become established were the planted trees and shade intolerant natural shrubs. Figures 3.1 - 3.8 depict the development of herbs and shrubs over the ten year period. Generally, the herb layer recovered and developed faster than the shrub layer regardless of treatment. The plots that were seeded to grass resulted in a faster rate of recovery for herbs. The shrub layer in the nonseeded plots developed faster and with a more regular progression of growth than the seeded plots. This could be a result of less competition. At the end of ten years plots Mx-1, 73-12 and 73-03 have developed a tall shrub layer and in the case of Mx-1 and 73-12, the low shrub layer appears to be decreasing in percent cover.

### 3.1.2 Grass-Legume Mixture

A grass and legume mixture of common timothy, red fescue, orchard grass, brome grass, alsike clover and alfalfa was seeded. The following table (Table 3.1) shows the growth of these species and the response to the treatments.

Red fescue, orchard grass, common timothy and alsike clover were consistently present in the plot. Out of these, red fescue showed the highest percent cover. It is a sod forming grass which vigorously competes for the soil surface and its mineral resources. Neither alfalfa nor alsike clover regenerated well. The pH of the soil was lower than the recognized level for satisfactory growth of alfalfa. The results for alsike clover, which is a recommended species for this area, are not clearly understood.

In response to the treatment - fertilizer, after ten years no significant difference between the fertilized and unfertilized plots was noted. The percent cover of grass in plot 73-05 is lower than the other two seeded plots. This may be due to the drier site conditions.

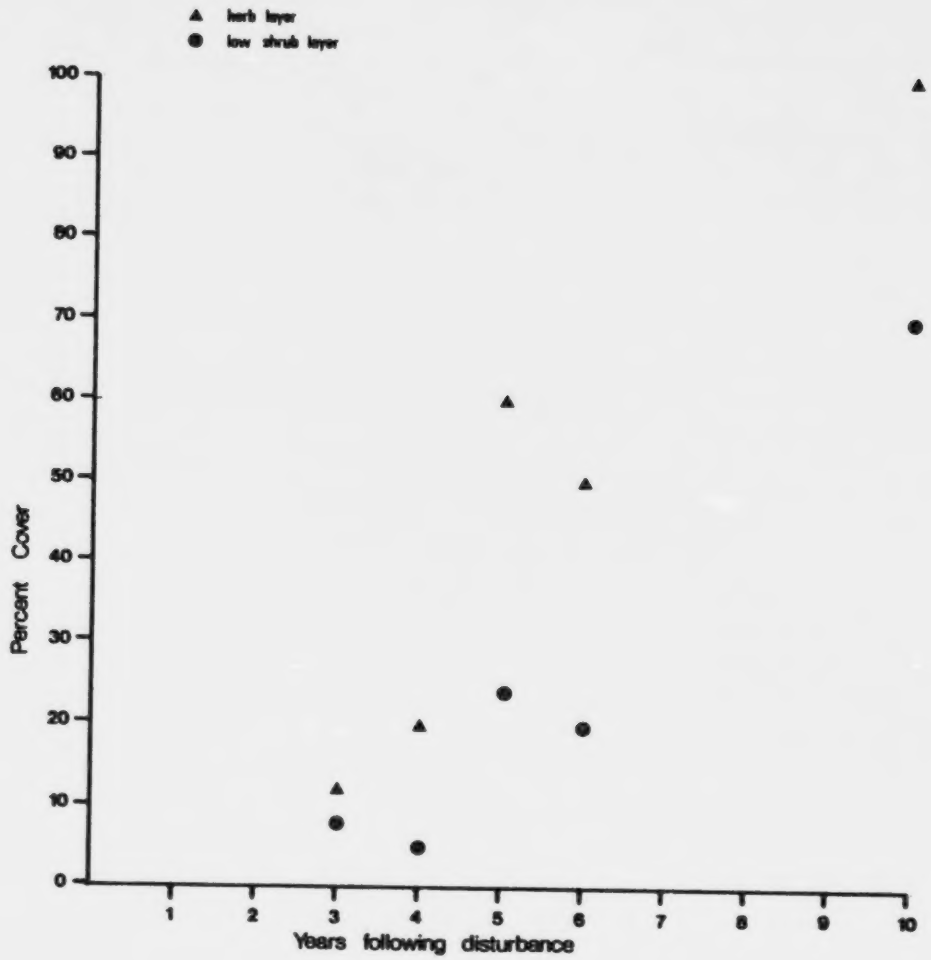

Figure 3.1 Development of herbs and shrubs over a ten year period for plot 73-03

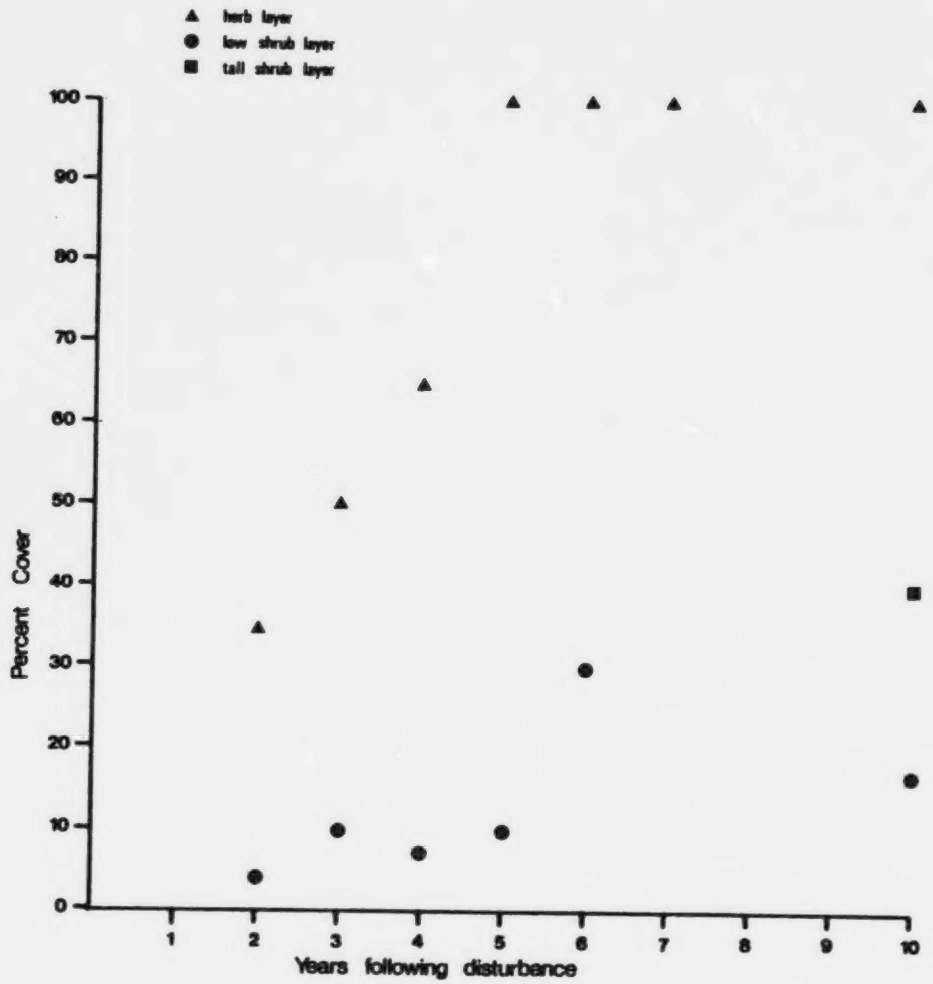

Figure 3.2 Development of herbs and shrubs over a ten year period for plot MX-I

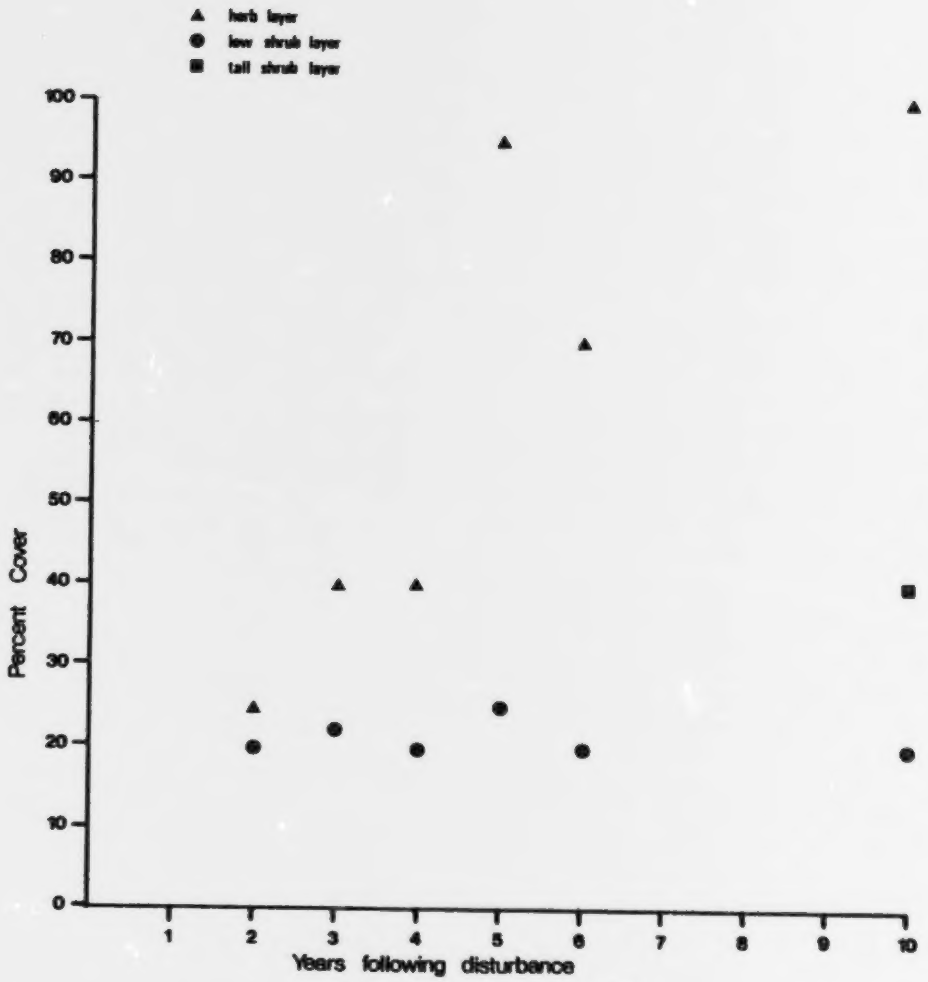

Figure 3.3 Development of herbs and shrubs over a ten year period for plot 73-12

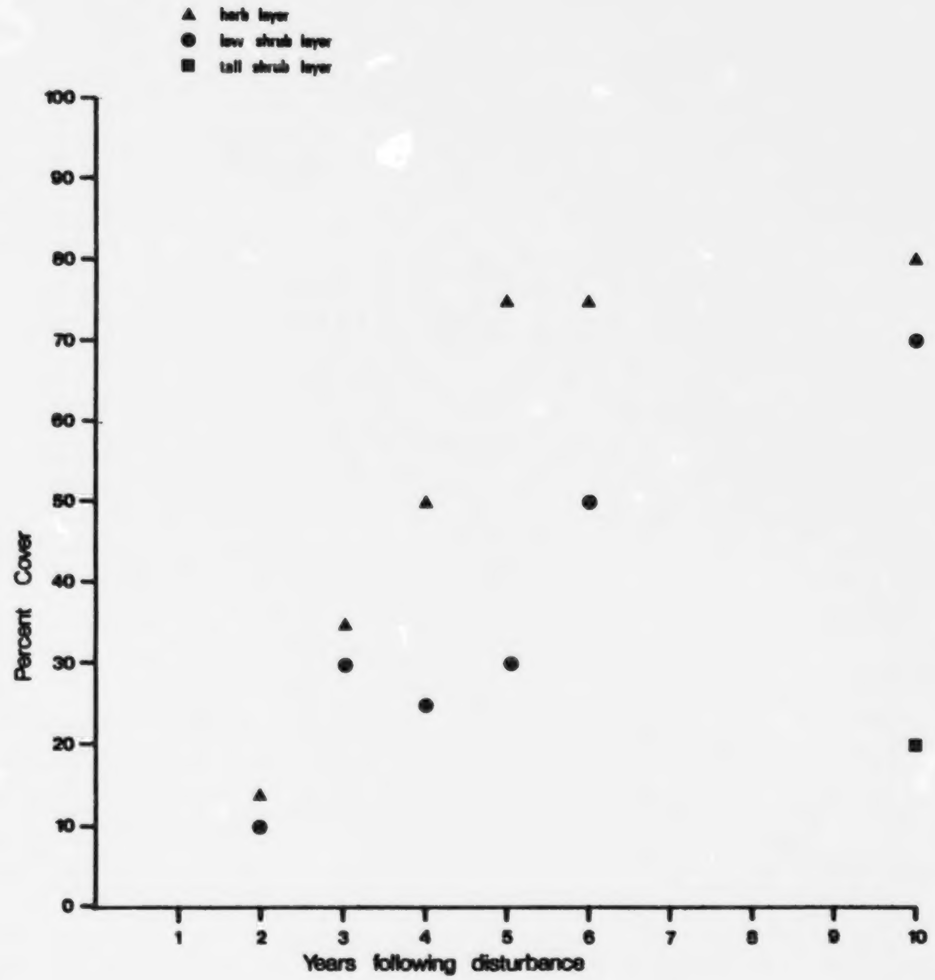

Figure 3.4 Development of herbs and shrubs over a ten year period for plot 73-03

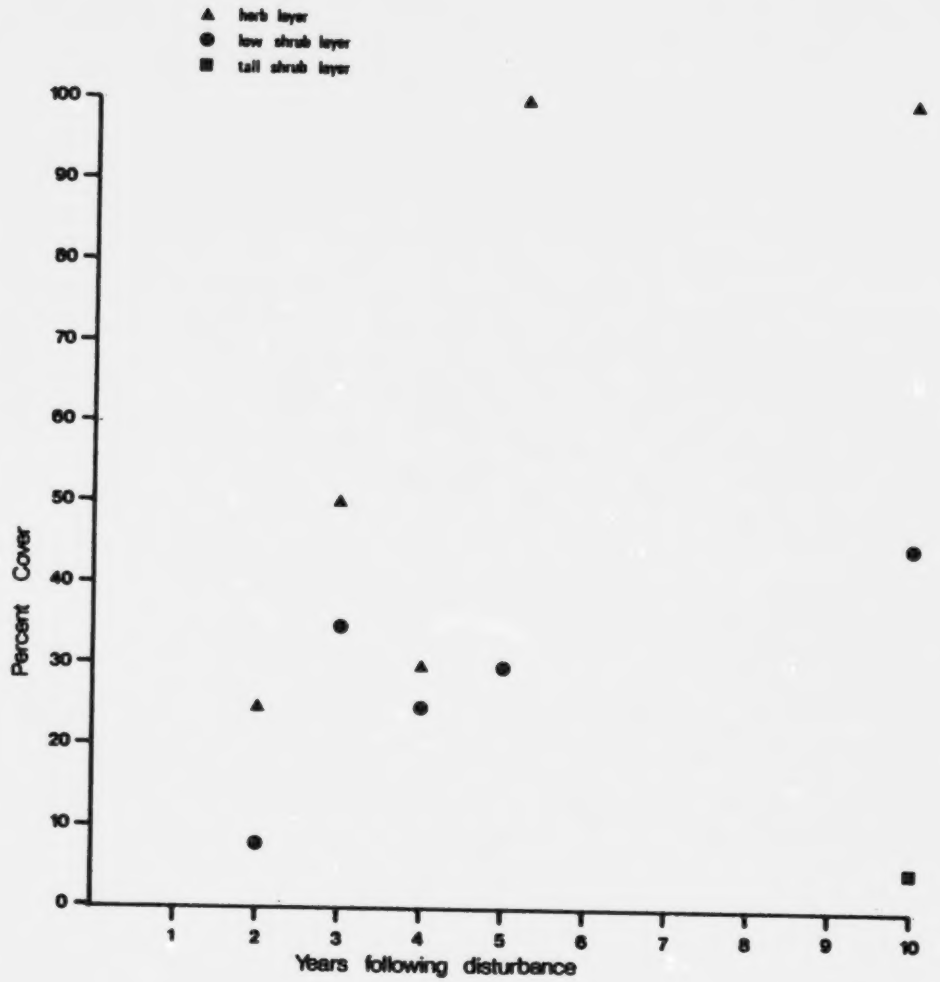

Figure 3.5 Development of herbs and shrubs over a ten year period for plot 73-04

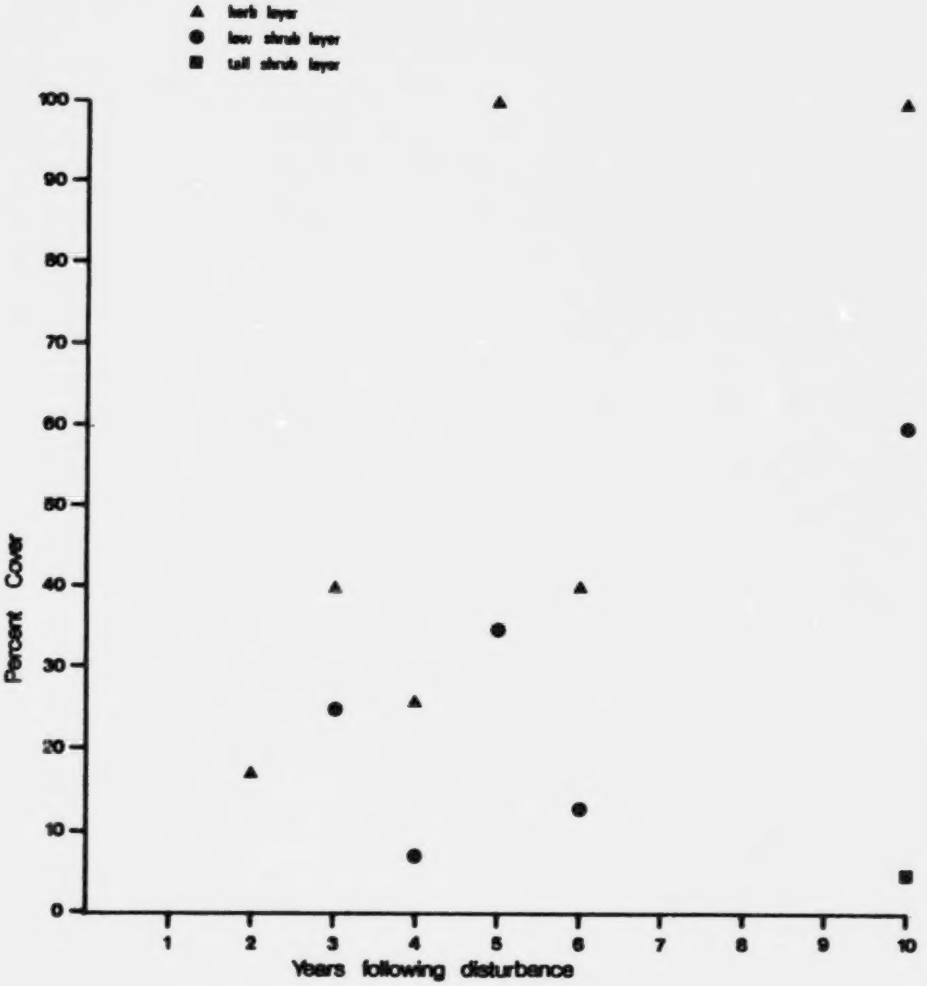

Figure 3.6 Development of herbs and shrubs over a ten year period for plot MX-2

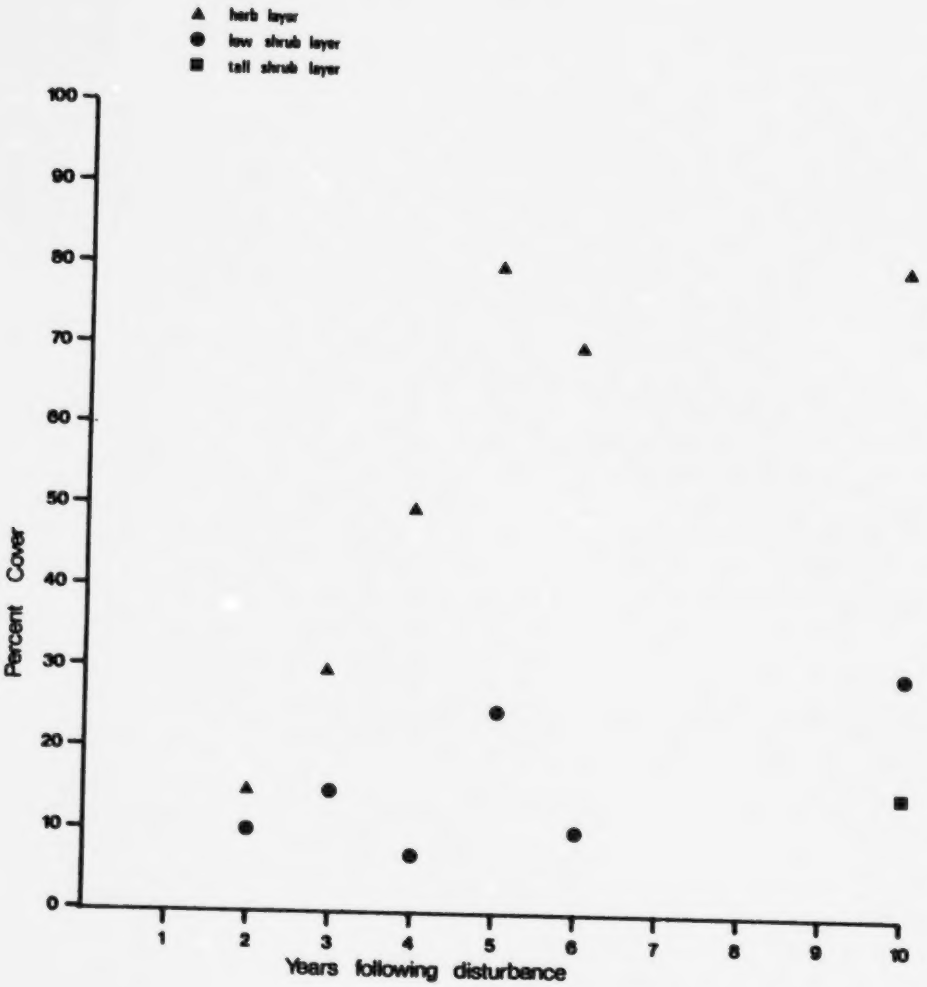

Figure 3.7 Development of herbs and shrubs over a ten year period for plot 73-11

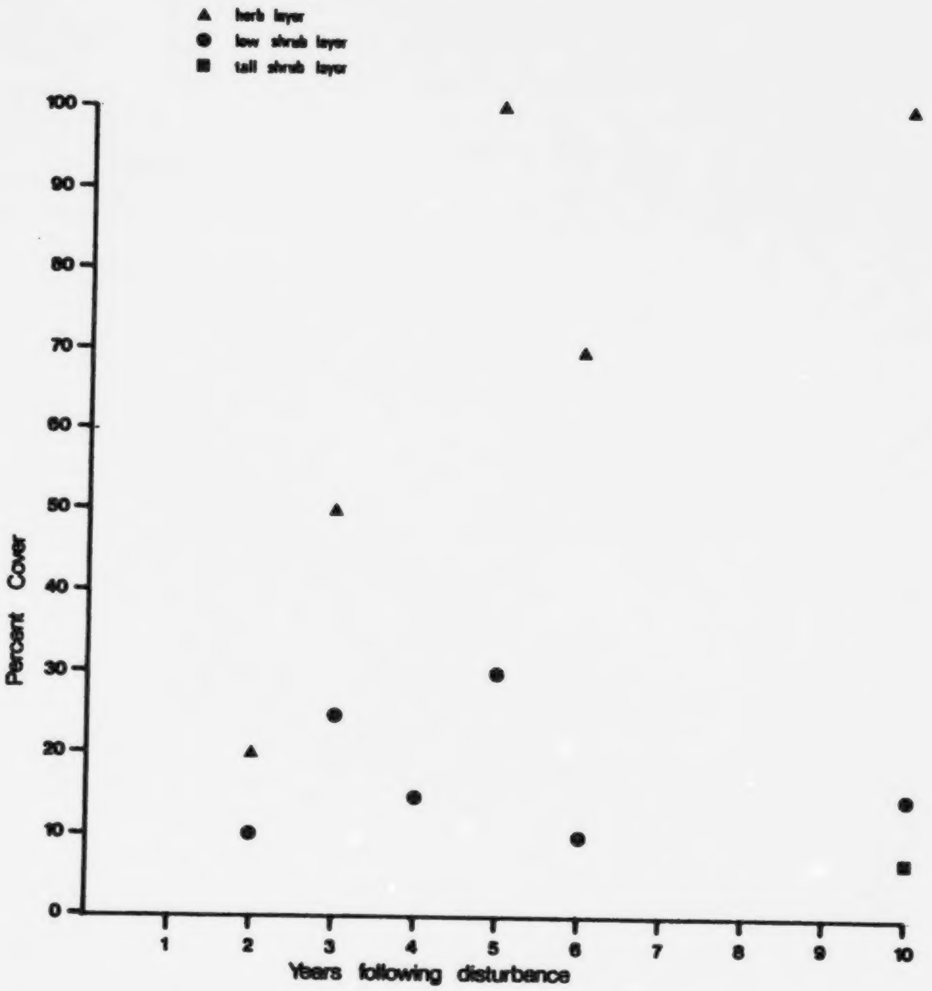

Figure 3.8 Development of herbs and shrubs over a ten year period for plot 73-05

Table 3.1

Response of Grass Mixture to Specified Treatments by Percent Cover

| Plot no. | Treatment[1] | Years | | | | | |
|---|---|---|---|---|---|---|---|
| 73-08 | C,_,_,_,_ | 1974 | 1975 | 1976 | 1977 | 1978 | 1982 |
| common timothy | | - | - | <1 | 2 | <1 | <1 |
| red fescue | | - | - | - | 1 | - | <1 |
| orchard grass | | - | - | - | - | - | - |
| brome grass | | - | - | - | - | - | - |
| alsike clover | | - | - | - | 1 | <1 | <1 |
| alfalfa | | - | - | - | - | - | - |
| Mx-1, | C,F,S,P,_ | | | | | | |
| common timothy | | 15 | 12 | 20 | 20 | 25 | 1 |
| red fescue | | - | - | - | 65 | 75 | 80 |
| orchard grass | | 5 | 10 | 7 | 10 | 30 | 10 |
| brome grass | | - | - | - | - | - | - |
| alsike clover | | 2 | - | 5 | 1 | 4 | 1 |
| alfalfa | | - | - | <1 | - | - | - |
| 73-12 | C,_,S,P,G | | | | | | |
| common timothy | | <5 | 4 | 10 | 10 | 5 | <1 |
| red fescue | | - | - | - | 25 | 60 | 85 |
| orchard grass | | <5 | 3 | 3 | 25 | 20 | 7 |
| brome grass | | - | - | - | - | <1 | 1 |
| alsike clover | | <5 | - | 3 | 5 | - | <1 |
| alfalfa | | - | - | - | - | - | - |
| 73-05 | C,F,S,_,_, | | | | | | |
| common timothy | | 1 | 4 | 7 | 10 | 3 | 4 |
| red fescue | | - | 5 | - | 30 | 40 | 40 |
| orchard grass | | 1 | <1 | 3 | 10 | 10 | 5 |
| brome grass | | - | - | - | - | <1 | 5 |
| alsike clover | | 1 | - | - | - | - | 2 |
| alfalfa | | - | - | - | - | - | - |

[1] The treatments are always listed in the following sequence - C,F,S,P,G. A dash indicates the treatment is lacking. The letters refer to: C - cleared, F - fertilized, S - grass-legume mixture seeded, P - planted to lodgepole pine, G - open to grazing.

## 3.2 FORESTRY

### 3.2.1 Number of Seedlings

### 3.2.1.1 Planted Seedlings versus Natural Regeneration

A tabulation of seedlings calculated per hectare is presented in Table 3.2. The actual seedling counts for 1973-1982 are in Appenidix C.

Table 3.2

Calculated number of seedlings per hectare from 1973 to 1978 and 1982 for lodgepole (lP) pine and white spruce (wS)

| | | | | | | | | Years | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1973 | | 1974 | | 1975 | | 1976 | | 1977 | | 1978 | | 1982 | |
| Plot | Treatment[1] | lP | wS | lP | wS | lP | wS | lP | wS | lP | wS | lP | wS | lP | wS |
| Planted | | | | | | | | | | | | | | | |
| Mr-1 | C,F,S,P,_ | 2,152.2 | | 1,926.3 | | 2,278.8 | | 2,152.2 | | 2,342.1 | | 2,468.7 | | 5,760.3 | 63.3 |
| 73-12 | C,_,S,P,G | 1,962.3 | 316.5 | 2,025.6 | | 2,468.7 | 253.2 | 1,519.2 | 126.6 | 2,342.1 | 316.5 | 2,405.4 | | 3,734.7 | 506.4 |
| 73-03 | C,F,_,P,_ | | | | | 2,785.2 | | 1,076.1 | | 2.785.2 | | 2,848.5 | | 5,443.8 | |
| 73-06 | C,F,_,P,G | 2,405.4 | | 2,532.0 | | 4,114.5 | | 4,747.5 | | 4,494.3 | | 5,000.7 | | NS | |
| Non-Planted | | | | | | | | | | | | | | | |
| 73-08 | C,_,_,_,_ | | | | | - | | | | 2,975.1 | | 8,862.0 | | 17,977.2 | 63.3 |
| 73-02 | C,F,S,_,_ | 126.6 | 126.6 | 126.6 | | 316.5 | 126.6 | 189.9 | 63.3 | 253.2 | | 379.8 | | NS | |
| 73-04 | C,F,_,_,_ | 63.3 | | | | 506.4 | | 1,076.1 | | 1,455.9 | | 2,911.8 | | 8,418.9 | 63.3 |
| Mr-2 | C,F,_,_,G | | | 63.3 | | 1,266.0 | | 1,835.7 | | 1,962.3 | | 2,152.2 | | 4,051.2 | |
| 73-11 | C,F,_,_,_ | | | | | 443.1 | | 633.0 | | 1,076.1 | | 1,519.2 | | 3,798.0 | |
| 73-10 | C,F,_,_,G | | 63.3 | | | 2,658.6 | | 3,798.0 | | 4,177.8 | | 5,507.1 | | NS | |
| 73-05 | C,F,S,_,_ | | | | | 126.6 | | 506.4 | | 379.8 | | 696.3 | | 2,088.9 | |
| 73-07 | C,F,S,_,_ | 63.3 | | 126.6 | | | | 506.4 | | 443.1 | | 822.9 | | NS | |

[1] The treatments are always listed in the following sequence - C,F,S,P,G. A dash indicates the treatments is lacking. The letters refer to: C - cleared, F - fertilized, S- grass-legume mixture seeded, P - planted to lodgepole pine, G- open to grazing.

[2] NS - not sampled

The number of lodgepole pine seedlings on the control cleared plot is significantly higher than on the other treatments. This may be due to:

- fifty percent of the planted plots were seeded with a grass-legume mixture therefore the nutrient and moisture availability and space for a seed to develop is reduced;
- competition from the planted trees and the grass-legume mixture which would have a good root system;
- on-site differences.
- the clean-up operation following clearing was not as intensive compared to the other plots.
- closer proximity to the seed source.
- the occurrence of a cluster of seeds germinating, producing two or more seedlings.

C, F, S, P, _[1] (plot no. Mx-1) versus C, F, S, _, _ (plot no. 73-05)

The naturally regenerating lodgepole pine seedlings are over fifty percent lower than in the seeded and planted plots. As well as competition from grass the results could be partially explained by: plot 73-05 is ecologically drier than plot Mx-1. The former is located on an upper slope position with a south-facing aspect while, plot Mx-1 is west-facing on a mid-slope position.

C, F, _, P, _ (plot no. 73-03) versus C, F, _, _, _ (plot no. 73-04 and 73-11) and C, F, _, _, G (plot no. Mx-2)

The mean number of seedlings is 5,443.8 in the plots planted to lodgepole pine and 6,108.5 in the non-planted plots; this difference is not substantial. However, the non-planted and grazed plot has a significantly lower number of seedlings.

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[1] The treatments are always listed in the following sequence - C,F,S,P,G. A dash indicates the treatment is lacking. The letters refer to: C - cleared, F - fertilized, S - grass-legume mixture seeded, P - planted to lodgepole pine, G - open to grazing.

### 3.2.1.2 Seeded versus Non-seeded Plots

C, F, S, P, _[1] (plot no. Mx-1) versus C, F, _, P, _ (plot no. 73-03)

The number of lodgepole pine seedlings in the seeded plot is not greatly higher than on the non-seeded plots. Therefore, this supports Clark and McLean's (1974) theory 'on the average, grass had no effect on germination or survival of planted seedlings'.

C, F, S, _, _ (plot no. 73-05) versus C, F, _, _, _ (plot no. 73-04 and 73-11)

The non-seeded plots had a substantially higher number of seedlings than the seeded plot. This may be attributed to site differences.

### 3.2.1.3 Lodgepole pine Seedlings versus White Spruce Seedlings Regeneration

The number of white spruce seedlings by natural regeneration is very low in comparison to natural regeneration of lodgepole pine. In moist areas with a cooler aspect the regeneration of white spruce seedlings may be somewhat improved.

### 3.2.2 Seedling Height Growth

Figure 3.9 and 3.10 represent the mean seedling heights for lodgepole pine and white spruce respectively. These results are summarized in Table 3.3. There are substantial differences in seedling heights between plots which are a result of on-site differences, seedlings (planted vs. non-planted) and treatments.

[1] The treatments are always listed in the following sequence - C,F,S,P,G. A dash indicates the treatment is lacking. The letters refer to: C - cleared, F - fertilized, S - grass-legume mixture seeded, P - planted to lodgepole pine, G - open to grazing.

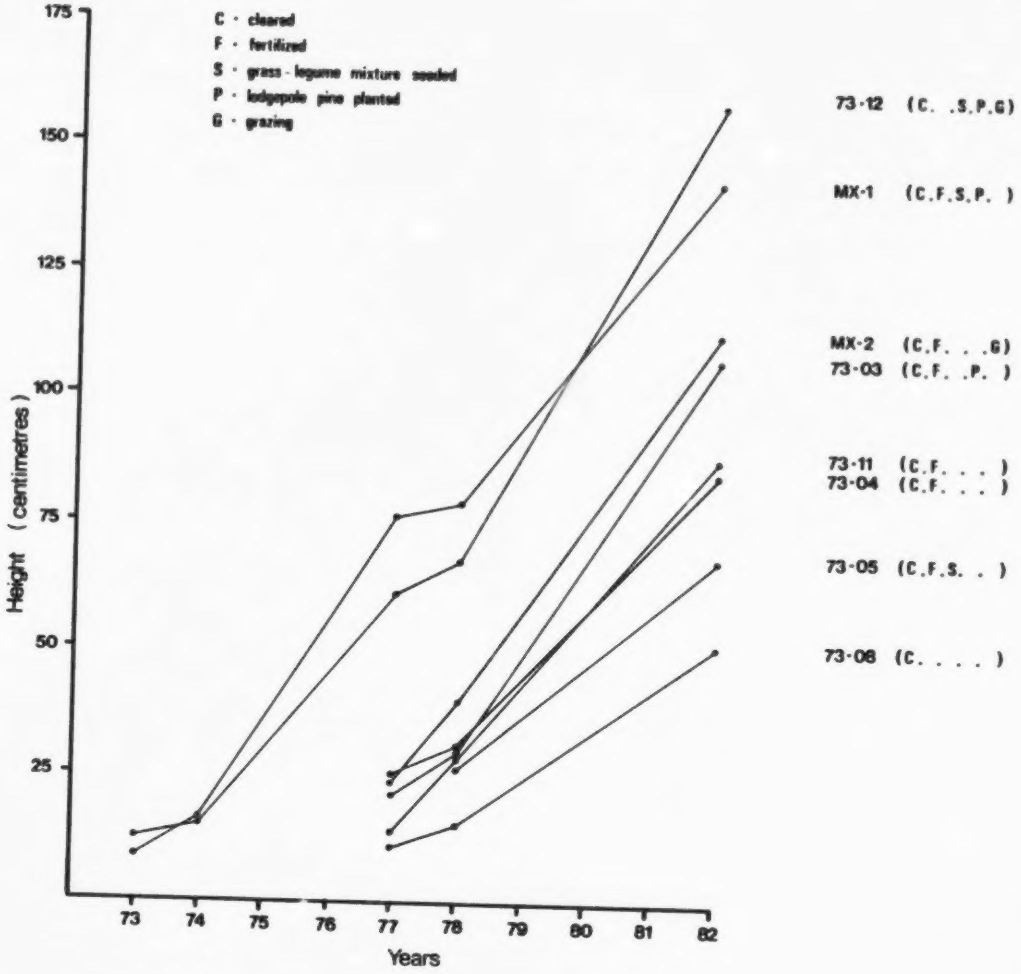

Figure 3.9 Mean Seedling Height for lodgepole pine

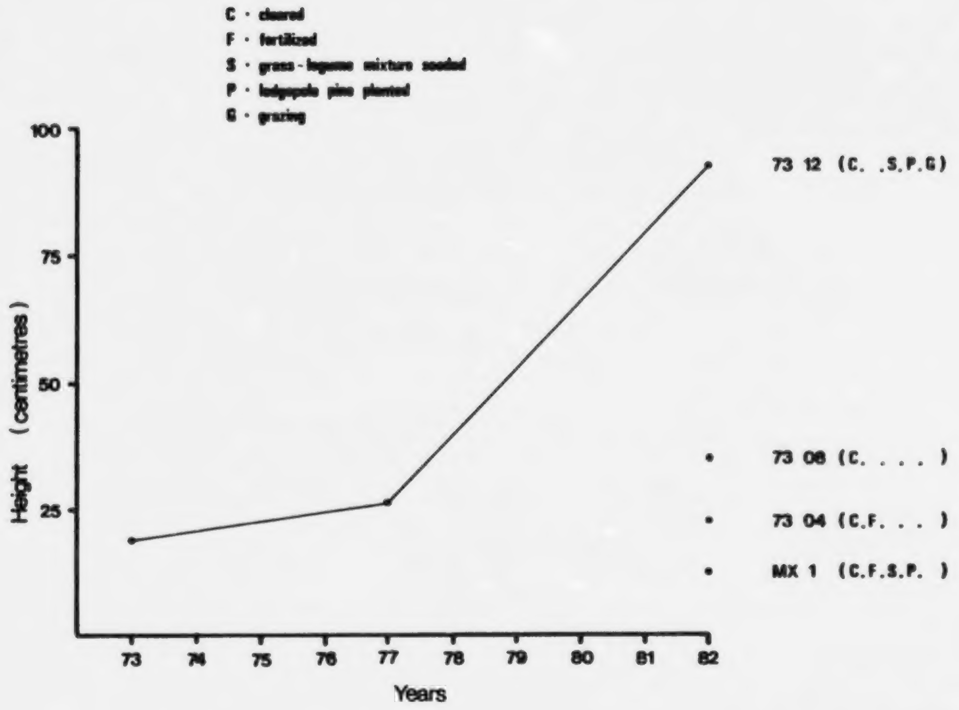

Figure 3.10 Mean Seedling Height for white spruce

Table 3.3
Summation of mean lodgepole pine seedling heights

| Treatment | Plot no(s). | Mean seedling Ht. (cm) |
|---|---|---|
| Planted | Mx-1, 73-12, 73-03 | 139.1 |
| Non-planted | 73-08, 73-04, Mx-2,<br>73-11, 73-05 | 82.9 |
| Planted & Seeded | 73-12 | 162.0 |
| Non-planted & Seeded | 73-05 | 70.6 |
| Planted & Fertilized | 73-03, | 109.7 |
| Non-planted & Fertilized | 73-04, 73-11, Mx-2 | 97.3 |
| Cleared | 73-08 | 52.1 |

The mean height of the non-planted plots is substantially lower than the planted plots. The former plots measurements are from natural regeneration which will take longer to establish therefore, will be lower in height if all other conditions remain the same. The plots that were both planted and seeded had the highest mean height. The height growth of the planted seedlings does not seem to be adversely affected by the grass-legume mixture. Also, the addition of fertilizer may have contributed to increased height growth.

## 3.3 BIOMASS

### 3.3.1 Biomass Following Clearing

The biomass production per square metre for 1976-1982 following clearing is presented below in Table 3.4. The total biomass for each year is calculated from the dry weight measurements in Appendix B.2.

Table 3.4

Total Biomass ($g/m^2$) from 1976 - 1982

| Plot No. | Treatments[1] | Biomass | | | |
|---|---|---|---|---|---|
| | | 1976 | 1977 | 1978 | 1982 |
| 73-08 | C,_,_,_,_ | 33.5 | 35.5 | 71.0 | 76.44 |
| Mx-1 | C,F,S,P,_ | 105.0 | 244.3 | 252.4 | 244.08 |
| 73-12 | C,_,S,P,G | 13.6 | 228.0 | 195.5 | 172.31 |
| Mx-2 | C,F,_,_,G | 62.1 | 147.0 | 208.7 | 248.39 |

The plot which received no treatments (plot 73-08) still has the lowest amount of biomass. The biomass of the two fertilized plots (Mx-1 and Mx-2) exceeded the non-fertilized plots. These results are consistent with another study (McLean and Clark, 1980) which showed seeded clearcuts yielded 2-4 times more herbage than unseeded areas.

[1] The treatments are always listed in the following sequence - C,F,S,P,G. A dash indicates the treatment is lacking. The letters refer to: C - cleared, F - fertilized, S - grass-legume mixture seeded, P - planted to lodgepole pine, G - open to grazing.

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# APPENDIX A
## VEGETATION DATA

The vegetation data within this appendix consists of the raw vegetation data by plot number and a plant species list. The vascular plant nomenclature follows Taylor and MacBryde (1977). The botanical nomenclature of the mosses is after Crum *et al* (1973); that of the lichens is after Hale and Culberson (1970).

Problems in making identifications to the specific level in some taxonomically difficult genera, or when less significant ecological differences exist between certain closely-related species, have resulted in the grouping of some species by genus.

The vegetation data comprises a list of plant species and its corresponding percent canopy cover, distribution and frequency. The following explanation of these terms and the codes is based on Walmsley *et al*. (1980).

$A_2$ - main tree canopy cover above 10 m in height

$B_1$ - woody plants between 2 m and 10 m tall; shrubs and advanced tree regeneration

$B_2$ - woody plants less than 2 m high: shrubs and established tree regeneration

C - herbaceous species, regardless of their height, and some low woody plants

D - mosses, lichens and tree seedlings growing on the dominant substrate

The percent canopy cover is an estimate of the percentage of the ground area covered by a vertical projection of the crown on to the ground surface.

The term distribution refers to the spatial pattern of individuals of each species. For simplicity, the distribution is expressed as a number. The distribution code is as follows: (Walmsley et al., 1980)

1 - rare individual, a single occurrence

2 - a few sporadically occurring individuals

3 - a single patch or clump of a species

4 - several sporadically occurring individuals

5 - a few patches or clumps of a species

6 - several well spaced patches or clumps

7 - continuous uniform occurrence of well spaced individuals

8 - continuous occurrence of a species with a few gaps in the distribution

9 - continuous dense occurrence of a species

Frequency, is an objective measure for monitoring changes in the vegetation. For each of the 10 subplots the presence of a species was checked. Total frequency is expressed as the percentage of the subplots the species was present in.

In the following tables - %C means percent canopy cover, D means distribution, and F means frequency.

## A.1 LIST OF FLORISTIC DATA BY PLOT

### Table A.1
### Floristic Data for Plot No. 73-13

| Horizon | Species | %C | D | F |
|---|---|---|---|---|
| $A_2$ | lodgepole pine | 60 | 7 | 90 |
| $B_1$ | white spruce | 2 | 2 | 0 |
| | willow | 3 | 2 | 10 |
| | red-osier dogwood | 2 | 5 | 10 |
| $B_2$ | white spruce | 2 | 1 | 40 |
| | Sitka mountain alder | 12 | 2 | 30 |
| | willow | 2 | 1 | 0 |
| | birch-leaved spirea | 7 | 5 | 80 |
| | high bush cranberry | 3 | 4 | 60 |
| | prickly rose | 5 | 5 | 50 |
| | bristly Nootka rose | 5 | 5 | 50 |
| | soopolallie | 7 | 5 | 30 |
| | western thimbleberry | 12 | 5 | 0 |
| | black blueberry | 3 | 5 | 10 |
| | trembling aspen | 1 | 2 | 0 |
| C | showy aster | 10 | 4 | 70 |
| | fireweed | 5 | 4 | 90 |
| | Canadian bunchberry | 5 | 4 | 99 |
| | heart-leaved arnica | 2 | 4 | 10 |
| | blue-bead clintonia | 4 | 5 | 40 |
| | American vetch | 25 | 7 | 99 |
| | northern twinflower | 2 | 5 | 20 |
| | false Solomon's-seal | 1 | 2 | 10 |
| | rough-leaved rice grass | 1 | 2 | 10 |
| | cream-colored peavine | <1 | 2 | 0 |
| | large-leaved rattlesnake orchid | 1 | 2 | 0 |
| | northern bedstraw | 1 | 2 | 10 |
| | common pink pyrola | 1 | 5 | 20 |
| | racemose pussytoes | 1 | 3 | 0 |
| D | *Pleurozium schreberi* | 90 | 8 | 99 |
| | *Ptilium crista-castrensis* | 5 | 5 | 70 |
| | *Hylocomium splendens* | 2 | 5 | 20 |
| | *Dicranum polysetum* | 2 | 5 | 40 |
| | *Peltigera leucophlebia* | 2 | 5 | 50 |
| | *Cladonia ecmocyna* | 1 | 5 | 0 |

## Table A.2
## Floristic Data for Plot No. 73-08

| Horizon | Species | %C | D | F |
|---|---|---|---|---|
| $B_2$ | lodgepole pine | 30 | 7 | 99 |
| | willows | 2 | 4 | 70 |
| | prickly rose | 35 | 6 | 90 |
| | high bush cranberry | 2 | 4 | 50 |
| | birch-leaved spirea | 40 | 6 | 80 |
| | black cottonwood | 2 | 4 | 80 |
| | Sitka mountain alder | 7 | 5 | 70 |
| | common saskatoon | 3 | 4 | 50 |
| | American red raspberry | 1 | 5 | 50 |
| | soopolallie | <1 | 2 | 10 |
| | white spruce | <1 | 2 | 40 |
| | twinberry honeysuckle | <1 | 2 | 10 |
| C | fireweed | 60 | 8 | 99 |
| | Rocky Mountain fescue | 5 | 4 | 50 |
| | bluejoint small reed grass | 35 | 6 | 99 |
| | showy aster | 10 | 6 | 70 |
| | hair bent grass | 15 | 6 | 90 |
| | white hawkweed | 30 | 7 | 99 |
| | Canadian bunchberry | 20 | 6 | 99 |
| | cream-coloured peavine | <1 | 2 | 30 |
| | common timothy | <1 | 4 | 50 |
| | rough-leaved rice grass | 7 | 6 | 90 |
| | wood reed grass | <1 | 2 | 10 |
| | red fescue | <1 | 4 | 20 |
| | yarrow | <1 | 2 | 30 |
| | Douglas' aster | 10 | 6 | 99 |
| | false Solomon's-seal | 1 | 5 | 50 |
| | blue-bead clintonia | 1 | 5 | 50 |
| | blue wild rye grass | <1 | 4 | 60 |
| | dwarf blueberry | 1 | 5 | 20 |
| | wild strawberry | 1 | 5 | 40 |
| | common dandelion | <1 | 2 | 70 |
| | brome grass | <1 | 4 | 30 |
| | slender wheat grass | <1 | 1 | 10 |
| | alsike clover | <1 | 2 | 20 |
| | violets | <1 | 1 | 10 |
| | spike trisetum | <1 | 4 | 30 |
| | northern twinflower | 2 | 5 | 60 |
| | old man's whiskers | <1 | 2 | 10 |
| | sedges | <1 | 2 | 10 |
| | western fescue | <1 | 2 | 30 |
| | fowl blue grass | <1 | 2 | 20 |
| | dwarf red blackberry | 1 | 4 | 30 |
| | northern bedstraw | 4 | 2 | 20 |
| | common pink pyrola | 1 | 5 | 30 |
| D | *Polytrichum juniperinum* | 30 | 6 | 100 |
| | *Pleurozium schreberi* | 5 | 5 | 70 |

## Table A.3
## Floristic Data for Plot No. Mx-1

| Horizon | Species | %C | D | F |
|---|---|---|---|---|
| $B_1$ | lodgepole pine | 40 | 7 | 100 |
| $B_2$ | lodgepole pine | 3 | 4 | 90 |
| | black cottonwood | 1 | 2 | 40 |
| | prickly rose | 7 | 5 | 90 |
| | birch-leaved spirea | 7 | 5 | 70 |
| | American red raspberry | <1 | 2 | 50 |
| | willow | <1 | 2 | 40 |
| | western thimbleberry | <1 | 1 | 10 |
| | twinberry honeysuckle | 1 | 2 | 20 |
| | common saskatoon | 1 | 1 | 20 |
| | white spruce | <1 | 2 | 30 |
| | Sitka mountain alder | 3 | 4 | 10 |
| | Sitka mountain-ash | <1 | 1 | 10 |
| C | orchard grass | 10 | 6 | 99 |
| | fireweed | 15 | 6 | 99 |
| | red fescue | 80 | 8 | 99 |
| | Douglas' aster | 10 | 7 | 99 |
| | alsike clover | 1 | 5 | 50 |
| | false Solomon's-seal | <1 | 2 | 10 |
| | wild strawberry | <1 | 2 | 30 |
| | dwarf red blackberry | <1 | 2 | 10 |
| | common timothy | 1 | 2 | 30 |
| | spike trisetum | <1 | 2 | 10 |
| | hair bent grass | <1 | 2 | 10 |
| | brome grass | 1 | 4 | 80 |
| | Canadian bunchberry | 1 | 5 | 40 |
| | showy aster | 1 | 4 | 20 |
| | bluejoint small reed grass | 3 | 5 | 30 |
| | dwarf blueberry | <1 | 1 | 10 |
| | few-flowered one-sided wintergreen | <1 | 1 | 10 |
| | white hawkweed | 1 | 4 | 30 |
| | kinnikinnick | <1 | 1 | 10 |
| | northern twinflower | 1 | 5 | 10 |
| | heart-leaved arnica | <1 | 1 | 10 |
| | cream-colored peavine | <1 | 1 | 10 |
| D | *Polytrichum juniperinum* | 10 | 5 | 80 |
| | *Pleurozium schreberi* | <1 | 3 | 20 |
| | *Cladonia spp.* | <1 | 2 | 10 |

## Table A.4
## Floristic Data for Plot No. 73-12

| Horizon | Species | %C | D | F |
|---|---|---|---|---|
| $B_1$ | trembling aspen | 3 | 4 | 30 |
| | lodgepole pine | 40 | 7 | 90 |
| | Sitka mountain alder | <1 | 2 | 20 |
| $B_2$ | red-osier dogwood | <1 | 1 | 10 |
| | western thimbleberry | <1 | 2 | 10 |
| | American red raspberry | <1 | 2 | 10 |
| | lodgepole pine | 7 | 4 | 90 |
| | trembling aspen | 7 | 5 | 50 |
| | prickly rose | 6 | 15 | 99 |
| | birch-leaved spirea | 5 | 5 | 70 |
| | common saskatoon | 5 | 5 | 70 |
| | soopolallie | <1 | 4 | 40 |
| | white spruce | <1 | 4 | 40 |
| | high bush cranberry | <1 | 2 | 20 |
| | willows | <1 | 2 | 30 |
| | twinberry honeysuckle | <1 | 2 | 10 |
| | Sitka mountain alder | 7 | 4 | 10 |
| C | wild strawberry | 3 | 5 | 60 |
| | fireweed | 40 | 8 | 99 |
| | red fescue | 85 | 8 | 99 |
| | kinnikinnick | <1 | 2 | 40 |
| | rough-leaved rice grass | 5 | 6 | 99 |
| | brome grass | 1 | 4 | 50 |
| | Canadian bunchberry | <1 | 3 | 20 |
| | orchard grass | 7 | 6 | 100 |
| | cream-coloured peavine | 4 | 3 | 50 |
| | bluebunch wheat grass | <1 | 2 | 30 |
| | spike trisetum | 3 | 5 | 60 |
| | common timothy | <1 | 2 | 40 |
| | showy aster | 1 | 5 | 40 |
| | American vetch | <1 | 2 | 10 |
| | Douglas' aster | 7 | 6 | 60 |
| | bluejoint small reed grass | 7 | 6 | 70 |
| | northern bedstraw | 1 | 4 | 30 |
| | yarrow | <1 | 3 | 40 |
| | northern twinflower | <1 | 5 | 60 |
| | alsike clover | <1 | 3 | 10 |
| | white hawkweed | 1 | 4 | 40 |
| | dwarf blueberry | <1 | 5 | 40 |
| | northern gentian | <1 | 1 | 10 |
| | stiff club-moss | <1 | 2 | 10 |
| | blue-bead clintonia | <1 | 2 | 10 |
| | dwarf red blackberry | <1 | 3 | 20 |
| | evergreen yellow violet | <1 | 1 | 10 |
| | field pussytoes | <1 | 1 | 10 |
| | narrow-leaved cow-wheat | <1 | 1 | 10 |
| D | *Polytrichum juniperinum* | 7 | 5 | 90 |
| | *Pleurozium schreberi* | <1 | 2 | 20 |
| | *Cladonia sp.* | <1 | 4 | 30 |
| | *Peltigera sp.* | <1 | 2 | 30 |

## Table A.5
## Floristic Data for Plot No. 73-03

| Horizon | Species | %C | D | F |
|---|---|---|---|---|
| $B_1$ | trembling aspen | 8 | 3 | 0 |
| | Sitka mountain alder | 15 | 5 | 10 |
| | lodgepole pine | 2 | 1 | 0 |
| | twinberry honeysuckle | 1 | 3 | 10 |
| | American red raspberry | 1 | 4 | 40 |
| $B_2$ | lodgepole pine | 40 | 7 | 60 |
| | trembling aspen | 15 | 5 | 30 |
| | birch-leaved spirea | 5 | 5 | 90 |
| | common saskatoon | 3 | 5 | 30 |
| | rose | 5 | 5 | 99 |
| | Sitka mountain alder | 8 | 5 | 10 |
| | willows | 5 | 5 | 0 |
| | high bush cranberry | 2 | 5 | 0 |
| C | fireweed | 50 | 7 | 99 |
| | bluejoint small reed grass | 20 | 6 | 99 |
| | white hawkweed | 2 | 4 | 99 |
| | Lindley's aster | 4 | 4 | 90 |
| | spike trisetum | 5 | 5 | 60 |
| | red fescue | 5 | 5 | 40 |
| | blue wild rye grass | 2 | 4 | 0 |
| | northern twinflower | 5 | 5 | 70 |
| | rough-leaved rice grass | 1 | 5 | 10 |
| | Canadian bunchberry | 2 | 4 | 60 |
| | wild strawberry | 2 | 4 | 0 |
| | hair bent grass | 3 | 5 | 10 |
| | common pink pyrola | 1 | 4 | 30 |
| | showy aster | 1 | 4 | 10 |
| | common timothy | 1 | 1 | 10 |
| | false Solomon's-seal | R | 1 | 10 |
| | yarrow | 1 | 5 | 10 |
| | blue-bead clintonia | R | 2 | 20 |
| D | *Polytrichum juniperinum* | 2 | 5 | 70 |
| | *Pleurozium schreberi* | 2 | 5 | 10 |
| | *Dicranum polysetum* | 1 | 3 | 20 |

## Table A.6

### Floristic Data for Plot No. 73-04

| Horizon | Species | %C | D | F |
|---|---|---|---|---|
| $B_1$ | Sitka mountain alder | 5 | 5 | 70 |
| | lodgepole pine | 1 | 2 | 20 |
| $B_2$ | lodgepole pine | 20 | 7 | 99 |
| | Sitka mountain alder | <1 | 2 | 30 |
| | birch-leaved spirea | 15 | 7 | 99 |
| | black cottonwood | <1 | 1 | 10 |
| | prickly rose | 10 | 6 | 99 |
| | white spruce | <1 | 1 | 10 |
| | common saskatoon | 1 | 4 | 20 |
| | high bush cranberry | 1 | 4 | 60 |
| | twinberry honeysuckle | <1 | 2 | 10 |
| | western mountain-ash | <1 | 2 | 10 |
| | red-osier dogwood | <1 | 2 | 10 |
| | American red raspberry | <1 | 4 | 40 |
| | willow | <1 | 1 | 10 |
| | trembling aspen | <1 | 3 | 20 |
| C | fireweed | 60 | 8 | 99 |
| | bluejoint small reed grass | 70 | 8 | 99 |
| | Canadian bunchberry | 5 | 6 | 99 |
| | few-flowered one-sided wintergreen | <1 | 3 | 30 |
| | white hawkweed | 6 | 7 | 99 |
| | showy aster | 5 | 5 | 40 |
| | northern bedstraw | 7 | 5 | 40 |
| | dwarf blueberry | 1 | 5 | 40 |
| | spike trisetum | 15 | 7 | 70 |
| | rough-leaved rice grass | 5 | 5 | 40 |
| | Douglas' aster | 10 | 6 | 60 |
| | common dandelion | 4 | 3 | 20 |
| | sedge | 2 | 4 | 60 |
| | hair bent grass | 1 | 3 | 30 |
| | northern twinflower | 3 | 5 | 70 |
| | blue-bead clintonia | 1 | 3 | 40 |
| | common timothy | <1 | 2 | 30 |
| | wild strawberry | <1 | 2 | 20 |
| | false Solomon's-seal | 2 | 4 | 70 |
| | western fescue | 1 | 3 | 30 |
| | slender wheat grass | <1 | 2 | 20 |
| | American vetch | <1 | 2 | 10 |
| | yarrow | <1 | 3 | 20 |
| D | *Polytrichum juniperinum* | 5 | 5 | 60 |
| | *Pleurozium schreberi* | 5 | 5 | 80 |
| | *Dicranum fuscescens* | <1 | 2 | 20 |
| | *Cladonia spp.* | <1 | 2 | 10 |

Table A.7
Floristic Data for Plot No. Mx-2

| Horizon | Species | %C | D | F |
|---|---|---|---|---|
| $B_1$ | Sitka mountain alder | 5 | 4 | 20 |
| $B_2$ | white spruce | <1 | 1 | 0 |
| | American red raspberry | <1 | 2 | 20 |
| | lodgepole pine | 30 | 6 | 99 |
| | common saskatoon | <1 | 2 | 20 |
| | birch-leaved spirea | 20 | 7 | 99 |
| | prickly rose | 10 | 6 | 99 |
| | soopolallie | 1 | 4 | 50 |
| | twinberry honeysuckle | <1 | 2 | 10 |
| | willows | <1 | 2 | 20 |
| | high bush cranberry | 1 | 3 | 40 |
| | western thimbleberry | 1 | 3 | 20 |
| | black swamp gooseberry | <1 | 1 | 0 |
| | Sitka mountain alder | 5 | 4 | 10 |
| | trembling aspen | <1 | 1 | 10 |
| C | fireweed | 75 | 8 | 99 |
| | bluejoint small reed grass | 75 | 8 | 99 |
| | showy aster | 10 | 6 | 80 |
| | Canadian bunchberry | 2 | 5 | 90 |
| | Douglas' aster | 20 | 7 | 90 |
| | wild strawberry | 10 | 6 | 90 |
| | northern bedstraw | 1 | 5 | 30 |
| | dwarf blueberry | <1 | 3 | 30 |
| | northern twinflower | <1 | 3 | 30 |
| | white hawkweed | 5 | 4 | 90 |
| | common pink pyrola | <1 | 1 | 10 |
| | sedge | <1 | 2 | 20 |
| | common dandelion | 7 | 5 | 90 |
| | red fescue | 3 | 5 | 40 |
| | brome grass | 1 | 5 | 30 |
| | spike trisetum | 10 | 7 | 90 |
| | rough-leaved rice grass | 10 | 6 | 80 |
| | hair bent grass | 5 | 5 | 60 |
| | Kentucky blue grass | <1 | 1 | 10 |
| | early blue violet | <1 | 2 | 40 |
| | Indian paintbrush | <1 | 2 | 20 |
| | slender wheat grass | <1 | 1 | 10 |
| | heart-leaved arnica | <1 | 1 | 0 |
| | cream-coloured peavine | <1 | 1 | 10 |
| | northwestern sedge | <1 | 2 | 20 |
| | western fescue | <1 | 1 | 0 |
| | common timothy | <1 | 2 | 20 |
| | blue wild rye grass | <1 | 1 | 10 |
| | yarrow | 1 | 3 | 30 |
| | kinnikinnick | <1 | 2 | 20 |
| | pussytoes | <1 | 1 | 10 |
| | blue-bead clintonia | <1 | 2 | 10 |
| D | *Polytrichum juniperinum* | 25 | 7 | 99 |
| | *Pleurozium schreberi* | 1 | 4 | 30 |
| | *Dicranum fuscescens* | <1 | 1 | 10 |
| | *Cladonia sp.* | 7 | 5 | 40 |

## Table A.8

## Floristic Data for Plot No. 73-11

| Horizon | Species | %C | D | F |
|---|---|---|---|---|
| $B_1$ | lodgepole pine | 10 | 5 | 10 |
| | Sitka mountain alder | 12 | 4 | 10 |
| $B_2$ | lodgepole pine | 15 | 4 | 99 |
| | soopolallie | 4 | 5 | 30 |
| | birch-leaved spirea | 3 | 4 | 90 |
| | prickly rose | 5 | 4 | 99 |
| | willows | 3 | 4 | 10 |
| | American red raspberry | 1 | 4 | 10 |
| | common saskatoon | 1 | 2 | 20 |
| | high bush cranberry | 2 | 5 | 20 |
| C | dwarf blueberry | 3 | 5 | 20 |
| | brome grass | 4 | 4 | 10 |
| | rough-leaved rice grass | 5 | 4 | 50 |
| | false Solomon's-seal | 1 | 4 | 0 |
| | blue-bead clintonia | 1 | 4 | 10 |
| | hair bent grass | 1 | 4 | 10 |
| | fowl blue grass | 1 | 4 | 10 |
| | spike trisetum | 1 | 4 | 10 |
| | kinnikinnick | 1 | 4 | 10 |
| | fireweed | 60 | 7 | 99 |
| | Lindley's aster | 2 | 4 | 90 |
| | red fescue | 80 | 8 | 99 |
| | brome grass | 3 | 4 | 50 |
| | showy aster | 2 | 4 | 40 |
| | common timothy | 2 | 4 | 50 |
| | orchard grass | 2 | 4 | 60 |
| | American vetch | 1 | 4 | 10 |
| | white hawkweed | 1 | 4 | 40 |
| | northern twinflower | 2 | 5 | 60 |
| | Canadian bunchberry | 1 | 2 | 70 |
| | northern bedstraw | 1 | 2 | 99 |
| | bluejoint small reed grass | 3 | 5 | 40 |
| | wild strawberry | 1 | 4 | 10 |
| | pyrola | 1 | 2 | 99 |
| | slender wheat grass | 1 | 2 | 10 |
| D | *Polytrichum juniperinum* | 2 | 5 | 50 |
| | *Pleurozium schreberi* | 1 | 5 | 10 |
| | *Ceratodon purpureus* | 1 | 5 | 0 |

## Table A.9
## Floristic Data for Plot No. 73-05

| Horizon | Species | %C | D | F |
|---|---|---|---|---|
| $B_1$ | lodgepole pine | 3 | 1 | 0 |
| | Sitka mountain alder | 4 | 1 | 0 |
| $B_2$ | lodgepole pine | 7 | 2 | 0 |
| | western thimbleberry | 5 | 5 | 20 |
| | common saskatoon | 2 | 2 | 20 |
| | birch-leaved spirea | 4 | 4 | 99 |
| | prickly rose | 3 | 4 | 99 |
| | high bush cranberry | 2 | 4 | 50 |
| | soopolallie | 1 | 4 | 50 |
| | Drummond's willow | 3 | 5 | 0 |
| | willow | 1 | 5 | 10 |
| | American red raspberry | 1 | 4 | 0 |
| C | dwarf blueberry | 1 | 2 | 40 |
| | wild strawberry | 1 | 4 | 0 |
| | showy aster | 3 | 4 | 70 |
| | fireweed | 60 | 7 | 99 |
| | northern twinflower | 8 | 5 | 70 |
| | American vetch | 1 | 2 | 20 |
| | Lindley's aster | 1 | 2 | 40 |
| | white hawkweed | 1 | 4 | 40 |
| | rough-leaved rice grass | 8 | 5 | 90 |
| | kinnikinnick | 1 | 5 | 30 |
| | false Solomon's-seal | 1 | 4 | 20 |
| | northern bedstraw | 2 | 4 | 80 |
| | bluejoint small reed grass | 10 | 6 | 50 |
| | common timothy | 4 | 5 | 70 |
| | brome grasses | 5 | 5 | 60 |
| | orchard grass | 5 | 5 | 60 |
| | red fescue | 40 | 7 | 99 |
| | slender wheat grass | 2 | 5 | 10 |
| | heart-leaved arnica | 1 | 2 | 10 |
| | spike trisetum | 3 | 5 | 0 |
| | alsike clover | 2 | 1 | 0 |
| | common dandelion | 1 | 4 | 40 |
| | Canadian bunchberry | 1 | 4 | 99 |
| | hair bent grass | 2 | 5 | 0 |
| D | *Polytrichum juniperinum* | 10 | 5 | 99 |
| | *Pleurozium schreberi* | 1 | 3 | 10 |
| | *Cladina rangiferina* | 1 | 5 | 10 |
| | *Ceratodon purpureus* | 2 | 5 | 60 |
| | *Cladina arbuscula* | 1 | 5 | 10 |

## A.2 PLANT SPECIES LIST

| COMMON NAME | BOTANICAL NAME |
|---|---|
| Tree Species | |
| lodgepole pine | *Pinus contorta var. latifolia* |
| trembling aspen | *Populus tremuloides* |
| white spruce | *Picea glauca* |
| Shrub Species | |
| American red raspberry | *Rubus idaeus* |
| birch-leaved spirea | *Spiraea betulifolia* |
| black blueberry | *Vaccinium membranaceum* |
| black cottonwood | *Populus balsamifera subsp. trichocarpa* |
| black swamp gooseberry | *Ribes lacustre* |
| bristly Nootka rose | *Rosa nutkana* |
| common saskatoon | *Amelanchier alnifolia* |
| high bush cranberry | *Viburnum edule* |
| prickly rose | *Rosa acicularis* |
| red-osier dogwood | *Cornus sericea* |
| rose | *Rosa sp.* |
| Sitka mountain alder | *Alnus viridis subsp. sinuata* |
| Sitka mountain-ash | *Sorbus sitchensis* |
| soopolallie | *Shepherdia canadensis* |
| twinberry honeysuckle | *Lonicera involucrata* |
| western thimbleberry | *Rubus parviflorus subsp. parviflorus* |
| willows | *Salix spp.* |
| Herb Species | |
| alfalfa | *Medicago sativa* |
| alsike clover | *Trifolium hybridum* |
| American vetch | *Vicia americana* |
| blue-bead clintonia | *Clintonia uniflora* |
| bluebunch wheat grass | *Agropyron spicatum* |
| bluejoint small reed grass | *Calamagrostis canadensis* |
| blue wild rye grass | *Elymus glaucus* |
| brome grass | *Bromus inermis* |
| Canadian bunchberry | *Cornus canadensis* |
| common dandelion | *Taraxacum officinale* |
| common pink pyrola | *Pyrola asarifolia* |
| common timothy | *Phleum pratense* |
| cream-coloured peavine | *Lathyrus ochroleucus* |

| COMMON NAME | BOTANICAL NAME |
|---|---|
| Herb Species (continued) | |
| Douglas' aster | *Aster subspicatus* |
| dwarf blueberry | *Vaccinium caespitosum* |
| dwarf red blackberry | *Rubus pubescens* |
| early blue violet | *Viola adunca* |
| evergreen yellow violet | *Viola orbiculata* |
| false Solomon's-seal | *Smilacina racemosa* |
| few-flowered one-sided wintergreen | *Orthilia secunda subsp. secunda* |
| field pussytoes | *Antennaria neglecta* |
| fireweed | *Epilobium angustifolium* |
| fowl blue grass | *Poa palustris* |
| hair bent grass | *Agrostis scabra* |
| heart-leaved arnica | *Arnica cordifolia* |
| Indian paintbrush | *Castilleja miniata* |
| Kentucky blue grass | *Poa pratensis* |
| kinnikinnick | *Arctostaphylos uva-ursi* |
| large-leaved rattlesnake orchid | *Goodyera oblongifolia* |
| Lindley's aster | *Aster ciliolatus* |
| narrow-leaved cow-wheat | *Melampyrum lineare* |
| northern bedstraw | *Galium boreale* |
| northern gentian | *Gentianella amarella* |
| northern twinflower | *Linnaea borealis* |
| northwestern sedge | *Carex concinnoides* |
| old man's whiskers | *Geum triflorum* |
| orchard grass | *Dactylis glomerata* |
| pussytoes | *Antennaria spp.* |
| pyrola | *Pyrola sp.* |
| racemose pussytoes | *Antennaria racemosa* |
| red fescue | *Festuca rubra* |
| Rocky Mountain fescue | *Festuca saximontana* |
| rough-leaved rice grass | *Oryzopsis asperifolia* |
| sedges | *Carex spp.* |
| showy aster | *Aster conspicuus* |
| slender wheat grass | *Agropyron pauciflorum* |
| spike trisetum | *Trisetum spicatum* |
| stiff club-moss | *Lycopodium annotinum* |
| violets | *Viola spp.* |
| western fescue | *Festuca occidentalis* |
| white hawkweed | *Hieracium albiflorum* |
| wild strawberry | *Fragaria virginiana* |
| wood reed grass | *Cinna latifolia* |
| yarrow | *Achillea millefolium* |

| **COMMON NAME** | **BOTANICAL NAME** |
|---|---|
| Moss Species | |
| | *Ceratodon purpureus* |
| | *Dicranum fuscescens* |
| | *Dicranum polysetum* |
| | *Hylocomium splendens* |
| | *Pleurozium schreberi* |
| | *Polytrichum juniperinum* |
| | *Ptilium crista-castrensis* |
| Lichen Species | |
| | *Cladina arbuscula* |
| | *Cladina rangiferina* |
| | *Cladonia ecmocyna* |
| | *Cladonia spp.* |
| | *Peltigera leucophlebia* |
| | *Peltigera spp.* |

# APPENDIX B

## BIOMASS DATA

The symbols used for the elements analyzed are the standard chemical symbols. The following is a key to the symbols:

| | |
|---|---|
| N | nitrogen |
| P | phosphorus |
| K | potassium |
| Ca | calcium |
| Mg | magnesium |
| S | sulphur |
| B | boron |
| Cu | copper |
| Fe | iron |
| Mn | manganese |
| Zn | zinc |
| Se | selenium |

Selenium was analyzed in only a few species. A cross comparison of species was attempted. For example, a predominant grass, bluejoint small reed grass, was chosen from an unfertilized plot (73-08) and then again from a fertilized plot (Mx-2).

## B.1 BIOMASS NUTRIENT ANALYSIS

Table B.1

Nutrient Analysis by Plant Species

| Plot No. | Plant Species | N % | P % | K % | Ca % | Mg % | S % | B Mg/Kg | Cu Mg/kg | Fe Mg/kg | Mn Mg/kg | Zn Mg/kg | Se ug/kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  | NUTRIENTS |  |  |  |  |  |  |
| 73-08 | prickly rose | 1.100 | 0.334 | 1.007 | 0.837 | 0.200 | 0.111 | 56.2 | 4.9 | 88.9 | 71.4 | 21.0 | 64.0 |
|  | black cottonwood | N[1] | 0.212 | 1.808 | 0.790 | 0.113 | 0.05 | 38.5 | 4.2 | 63.7 | 30.1 | 22.4 |  |
|  | birch-leaved spirea | 0.842 | 0.203 | 0.646 | 0.793 | 0.218 | 0.06 | 38.1 | 4.2 | 93.8 | 539.0 | 140.0 |  |
|  | white hawkweed | 0.655 | 0.192 | 2.331 | 0.782 | 0.151 | 0.03 | 26.7 | 7.7 | 200.9 | 212.8 | 51.8 |  |
|  | bluejoint small reed grass | 0.857 | 0.208 | 1.130 | 0.433 | 0.069 | 0.05 | 30.0 | 2.8 | 112.0 | 1 101.1 | 19.6 | 140.0 |
|  | fireweed | 0.370 | 0.102 | 0.915 | 1.225 | 0.416 | 0.03 | 57.5 | 4.2 | 74.2 | 423.5 | 41.3 | 470.0 |
|  | Canadian bunchberry | 0.644 | 0.270 | 1.109 | 3.227 | 0.683 | 0.117 | 51.6 | 2.8 | 312.9 | 130.2 | 21.7 |  |
|  | showy aster | 0.922 | 0.320 | 2.271 | 1.994 | 0.366 | 0.06 | 56.2 | 16.1 | 206.5 | 337.4 | 123.9 |  |
|  | general biomass[2] | 1.054 | 0.243 | 1.157 | 1.413 | 0.300 | 0.07 | 33.0 | 8.4 | 786.8 | 525.0 | 86.1 |  |
| Mx-1 | Lindley's aster | 1.142 | 0.372 | 2.716 | 1.565 | 0.252 | 0.06 | 30.5 | 21.0 | 78.4 | 78.4 | 94.5 |  |
|  | fireweed | N | 0.263 | 0.497 | 2.825 | 0.401 | 0.05 | 31.3 | 12.3 | 103.3 | 103.3 | 21.0 |  |
|  | Sitka mountain alder | 1.382 | 0.148 | 0.628 | 0.902 | 0.148 | 0.05 | 22.5 | 16.8 | 68.6 | 311.5 | 68.6 | 98.0 |
|  | red fescue | 0.590 | 0.109 | 0.636 | 0.480 | 0.083 | 0.04 | 3.1 | 4.9 | 311.5 | 817.6 | 16.1 | 87.0 |
|  | general biomass | 0.536 | 0.058 | 0.125 | 0.640 | 0.083 | 0.04 | 22.5 | 28.0 | 1 206.8 | 336.0 | 30.1 |  |
| 73-12 | dwarf blueberry | 1.069 | 0.136 | 0.518 | 0.704 | 0.174 | 0.06 | 43.1 | 4.2 | 54.6 | 1 443.4 | 79.8 |  |
|  | herb | N | 0.151 | 1.634 | 0.843 | 0.173 | 0.06 | 46.0 | 16.6 | 73.5 | 404.3 | 118.1 |  |
|  | northern twinflower | N | 0.124 | 1.208 | 1.215 | 0.238 | 0.06 | 17.2 | 8.4 | 89.6 | 133.0 | 26.6 |  |
|  | Lindley's aster | 1.697 | 0.283 | 2.786 | 1.740 | 0.248 | 0.12 | 57.9 | 17.5 | 82.6 | 155.4 | 109.2 |  |
|  | wild strawberry | 1.155 | 0.257 | 0.969 | 1.449 | 0.266 | 0.06 | 30.9 | 7.7 | 58.1 | 254.8 | 15.4 |  |
|  | Douglas' aster | N | 0.139 | 1.820 | 0.904 | 0.148 | 0.04 | 36.0 | 14.0 | 93.8 | 323.4 | 114.8 |  |
|  | Canadian bunchberry | N | 0.320 | 0.725 | 2.514 | 0.423 | 0.05 | 131.3 | 5.3 | 89.3 | 46.4 | 16.6 |  |
|  | prickly rose | 1.018 | 0.369 | 1.084 | 1.037 | 0.240 | 0.04 | 60.4 | 4.9 | 74.2 | 135.1 | 16.1 |  |
|  | birch-leaved spirea | 0.885 | 0.209 | 0.790 | 0.940 | 0.220 | 0.04 | 57.5 | 4.2 | 51.8 | 314.3 | 137.2 |  |
|  | northern bedstraw | 1.099 | 0.134 | 1.820 | 1.918 | 0.202 | 0.08 | 87.5 | 5.6 | 73.5 | 133.7 | 77.7 |  |
|  | fireweed | 0.874 | 0.224 | 1.044 | 1.715 | 0.622 | 0.04 | 44.5 | 6.3 | 69.3 | 127.4 | 56.7 |  |
|  | white hawkweed | N | 0.112 | 1.722 | 0.627 | 0.094 | 0.03 | 53.6 | 3.5 | 41.3 | 282.8 | 91.0 |  |
|  | red fescue | 0.660 | 0.156 | 0.866 | 0.522 | 0.095 | 0.08 | 37.2 | 4.2 | 91.0 | 635.6 | 18.2 | 123.0 |
|  | general biomass | 0.705 | 0.108 | 0.342 | 0.692 | 0.078 | 0.05 | 46.1 | 2.8 | 357.0 | 719.6 | 50.4 |  |
| Mx-2 | common dandelion | N | 0.097 | 3.880 | 1.722 | 0.132 | 0.05 | 21.2 | 5.0 | 57.0 | 157.0 | 16.0 |  |
|  | birch-leaved spirea | 0.870 | 0.325 | 0.655 | 1.477 | 0.269 | 0.05 | 59.6 | 4.2 | 82.6 | 466.2 | 100.8 |  |
|  | prickly rose | 0.842 | 0.184 | 0.587 | 1.043 | 0.160 | 0.05 | 56.6 | 4.9 | 128.1 | 102.9 | 37.1 |  |
|  | white hawkweed | 0.667 | 0.179 | 1.848 | 0.713 | 0.131 | 0.04 | 40.6 | 4.9 | 90.3 | 130.2 | 39.9 |  |
|  | fireweed | 0.493 | 0.196 | 0.951 | 1.434 | 0.314 | 0.04 | 30.5 | 3.5 | 115.5 | 113.4 | 24.5 |  |
|  | bluejoint small reed grass | 0.641 | 0.185 | 0.898 | 0.470 | 0.081 | 0.05 | 58.7 | 2.1 | 86.8 | 789.6 | 24.5 | 59.0 |
|  | straw[3] | 0.695 | 0.126 | 0.554 | 0.508 | 0.069 | 0.05 | 49.1 | 4.2 | 261.8 | 802.9 | 30.1 |  |
|  | forbs[4] | 0.375 | 0.046 | 0.127 | 1.147 | 0.109 | 0.03 | 47.4 | 7.7 | 911.4 | 301.0 | 38.5 |  |
|  | general biomass | 0.750 | 0.141 | 0.659 | 1.013 | 0.145 | 0.06 | 60.0 | 4.9 | 2394.0 | 603.4 | 46.2 |  |

Footnotes:

[1] not enough sample
[2] unidentifiable portions of leaves and stems
[3] unidentifiable grass stems
[4] unidentifiable stems

## B.2 BIOMASS DRY WEIGHT MEASUREMENTS

Table B.2

Dry Weight Measurements by Plant Species

| Plot No. | Species | Dry wt. (g/m$^2$) |
|---|---|---|
| 73-08 | prickly rose | 14.72 |
| | black cottonwood | .54 |
| | birch-leaved spirea | 9.13 |
| | white hawkweed | 5.18 |
| | bluejoint small reed grass | 21.67 |
| | fireweed | 4.46 |
| | Canadian bunchberry | 15.87 |
| | showy aster | 3.68 |
| | general biomass[1] | 1.13 |
| | false Solomon's-seal | .06 |
| | dwarf blueberry | Trace |
| Mx-1 | Lindley's aster | 5.31 |
| | fireweed | .13 |
| | Sitka mountain alder | 3.77 |
| | red fescue | 233.8 |
| | general biomass | 1.07 |
| | dwarf blueberry | Trace |
| 73-12 | dwarf blueberry | .98 |
| | herb | .30 |
| | northern twinflower | .16 |
| | Lindley's aster | 4.21 |
| | wild strawberry | 7.02 |
| | Douglas'aster | .51 |
| | Canadian bunchberry | .27 |
| | prickly rose | 2.51 |
| | birch-leaved spirea | 1.05 |
| | northern bedstraw | 1.19 |
| | fireweed | 1.27 |
| | white hawkweed | .51 |
| | red fescue | 56.33 |
| | general biomass | 96.0 |
| | few-flowered one-sided wintergreen | Trace |
| | pyrola | Trace |
| Mx-2 | common dandelion | .23 |
| | birch-leaved spirea | .84 |
| | prickly rose | 4.51 |
| | white hawkweed | 2.38 |
| | fireweed | 34.15 |
| | bluejoint small reed grass | 27.87 |
| | straw[2] | 115.28 |
| | forbs[3] | 40.71 |
| | general biomass | 22.35 |
| | Lindley's aster | .07 |
| | Canadian bunchberry | Trace |

Footnotes:

[1] unidentified portions of leaves and stems

[2] unidentified grass stems

[3] unidentified stems

# APPENDIX C

## SEEDLING COUNTS

The data-seedling counts for 1973 to 1982 are presented below. 1P and wS represent lodgepole pine and white spruce respectively. Planted refers to the treatment applied to the plot. The planted stock could not be distinguished from the naturally regenerating seedlings of lodgepole pine.

Table C.1

Number of Seedlings Per .08 Hectare Plot from 1973 to 1982 for Lodgepole Pine (1P) and White Spruce (wS)

| | | Years | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1973 | | 1974 | | 1975 | | 1976 | | 1977 | | 1978 | | 1982 | |
| Plot | Treatment[1] | IP | WS | IP | wS | IP | wS | IP | wS | IP | wS | IP | wS | IP | wS |
| Planted | | | | | | | | | | | | | | | |
| Mx-1 | C,F,S,P,_ | 34 | | 31 | | 36 | | 34 | | 37 | | 39 | | 91 | 1 |
| 73-12 | C,_,S,P,G | 31 | 5 | 32 | | 39 | 4 | 24 | 2 | 37 | 5 | 38 | | 59 | 8 |
| 73-03 | C,F,_,P,_ | | | | | 44 | | 17 | | 44 | | 45 | | 86 | |
| 73-06 | C,F,_,P,G | 38 | | 40 | | 65 | | 75 | | 71 | | 79 | | | |
| Non-Planted | | | | | | | | | | | | | | | |
| 73-08 | C,_,_,_,_ | | | | | | | | | 47 | | 140 | | 284 | 1 |
| 73-02 | C,F,S,_,_ | 2 | 2 | 2 | | 5 | 2 | 3 | 1 | 4 | | 6 | | | |
| 73-04 | C,F,_,_,_ | 1 | | | | 8 | | 17 | | 23 | | 46 | | 133 | 1 |
| Mx-2 | C,F,_,_,G | | | 1 | | 20 | | 29 | | 31 | | 34 | | 64 | |
| 73-11 | C,F,_,_,_ | | | | | 7 | | 10 | | 17 | | 24 | | 60 | |
| 73-10 | C,F,_,_,G | | 1 | | | 42 | | 60 | | 66 | | 87 | | | |
| 73-05 | C,F,S,_,_ | | | | | 2 | | 8 | | 6 | | 11 | | 33 | |
| 73-07 | C,F,S,_,_ | 1 | | 2 | | | | 8 | | 7 | | 13 | | | |

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[1] The treatments are always listed in the following sequence - C,F,S,P,G. A dash indicates the treatment is lacking. The letters refer to: C - cleared, F - fertilized, S - grass-legume mixture seeded, P - planted to lodgepole pine, G - open to grazing.

Plot 73-06, 73-02, 73-10 and 73-07 were not sampled in 1982.

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